4-9283-3

ENERGY, MINES AND RESOURCES CANADA

PRE-ENGINEERING ASSESSMENT OF ENERSOLVE PROJECT AT THE STANTON PIPES FOUNDRY

APRIL 30,1985

P.R. #9036.1

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PRE-ENGINEERING ASSESSMENT OF ENERSOLVE PROJECT AT THE STANTON PIPES FOUNDRY

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology

This report should be cited as DSS Contract Serial No: 0SQ84-00394

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CANMET PROJECT NO: 507802

CANMET SCIENTIFIC AUTHORITY: Mr. A.C.S. HAYDEN

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April 30, 1985

Energy, Mines and Resources Canada
CANMET, Energy Research Laboratories
555 Booth St.
Ottawa, Ontario
K1A 0G1

Attention: Mr. A.C.S. Hayden

Dear Sir:

Re: Pre-Engineering Assessment of Enersolve Demonstration
Project in Foundry
DSS Contract No: 0SQ84-00394
DSS Fil No: 02SQ.23440-4-9283-3

Enclosed please find ten copies of the draft report for the above study.

Preliminary indications are that significant potential savings exist for the annealing furnace at Stanton Pipes Ltd. A brief investigation of other foundries in Canada indicates that similar savings are possible in many other plants as well.

As discussed with your Mr. McDonald, the contract specified that only final reports, not draft copies, were to be submitted. He indicated that if your recommended revisions result in the total charges exceeding the original contract price, the price would be suitably amended.

We have had requests from some of the Foundries participating in the survey for a copy of the final report. Could you please advise us how you would like this to be handled.

The co-operation of the personnel at Stanton Pipes and the other foundries was a key in the successful completion of tnis project. We look forward to receiving your comments. Please do not hesitate to contact us if there are any questions.

Yours very truly,

C. Twigge-Molecey, Ph.D., P.Eng.
Associate

CT-M/tmd
Enclosure

cc: John W. McGill
(Supply and Services Canada)

PROJECT REPORT

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS
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P.R. #9036.1
File #9036.2

April 30, 1985

DISTRIBUTION:

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C.Twigge-Molecey - HA
S. Kumar - HA

* 4 copies with Appendices

DSS - 9036
ENERSOLVE DEMONSTRATION PROJECT

PRE-ENGINEERING ASSESSMENT OF ENERSOLVE PROJECT AT THE STANTON PIPES FOUNDRY

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S. Kumar

S. Kumar, P.Eng.

SUMMARY

Hatch Associates were retained by Supply and Services Canada to provide a pre-evaluation of the potential for increasing the efficiency of oil and gas utilization in Foundries. Stanton Pipes Ltd. in Hamilton was chosen as the site for this study. The plant produces ductile cast iron pressure pipes for water distribution systems. Current plant production is 23,000 tons/yr.

The natural gas consumption is about 130 million cf per year. The continuous furnace uses approximately 60% of this total. Field measurements indicate that the energy required to heat the pipes is only 15% of the total gas input. The burner controls are poor. The specific fuel consumption is 2.2 MMBTU/ton (including daily heat-up).

Approximately 62% of the losses are through the flue gases. A central recuperator to pre-heat combustion air and improve controls would have a total installed cost of $276,100 and annual operating savings of $132,900 with a resultant payback of 2.1 years (see Table 1).

Improvements to the combustion control, and an exhaust gas system for regulating furnace pressure would cost about $210,000 with a payback of 2.0 years (see Table 1). This option is an alternative to the recuperator option.

Another alternative is a regenerative burner (which combines the burner and regenerator in a single block) system which would have a total cost of $461,300 and a payback of 3.0 years (see Table 1). Although this is not the most economic option, the benefits will be greater if there are plans in the near future to replace most of the old burners on the furnace.

The current radiation curtain at the charge door and between zones could be improved by using an insulating material to lower the cold face temperature.

A brief survey was conducted of the potential for application of these energy conservation measures to other Canadian foundries. A total of 22 plants were contacted, which together comprise about 70% of all Canadian foundry production, and only two of the 13 respondents recover waste heat from the furnace flue gases.

A demonstration project to illustrate the benefits of waste heat recovery will be vital in encouraging other foundries to use waste heat recovery in reducing energy costs.

SOMMAIRE

Approvisionnements et Services Canada a engagé les services de la firme Hatch Associates pour effectuer la pré-évaluation du potentiel d'augmentation d'efficience de l'utilization de l'huile et du gaz dans les fonderies. La compagnie Stanton Pipes Ltd. à Hamilton, a été choisie comme l'emplacement pour ces études. L'usine de Stanton Pipes produit des tuyaux sous pression en fonte malléable pour systèmes de distribution de l'eau. La production actuelle de l'usine est de 23,000 tonnes par année.

La consommation de gaz naturel est d'environ 130 millions de pieds cubiques par année. Les fours continus utilisent près du 60% de ce total. Une évaluation effectué sur le terrain, révèle que l'énergie requise pour chauffer les tuyaux est de seulement 15% de la consommation totale de gaz. Les commandes du brûleurs sont médiocres. La consommation spécifique de combustible est de 2.2 MMBTU/tonne (y compris le réchauffement quotidien).

Près du 62% des pertes ont lieu au long des conduites des fumeé. Le coût total d'un récupérateur central réchauffant préalablement l'air de combustion et de l'amélioration des commandes, serait de $276,100, l'installation y compris, avec une économie annuelle d'exploitation de $132,900 récupérables en une période de 2.1 ans (voir Table 1).

Le coût des améliorations à effectuer à niveau des commandes de combustion, ainsi que du système d'évacuation de gaz brûlé pour contrôler la pression du four, serait d'environ $210,000 récupérables en 2.0 ans (voir Table 1). Ces options ne sont pas additionnelles.

Le coût total d'un système comprenant un brûleur régénérateur (combinant le brûleur et le récupérateur, le tout dans un seul bloc), serait de $461,300, récupérables en 3.0 ans (voir Table 1). Malgré le fait que celle-ci n'est pas l'option la plus économique, on en profitera davantage si dans l'avenir on planifierait de remplacer la plupart des anciens brûleurs du four.

Le rideau de radiation actuel dans la porte de charge et entre les zones pourrait être améliorée en utilisant un matériel isolant afin de réduire la température de la surface froide.

Une brève étude du potentiel d'utilisation de ces mesures de conservation d'énergie dans d'autres fonderies au Canada a été effectué. Un total de 22 usines (comprenant dans l'ensemble près du 70% du total de la production des fonderies au Canada) furent contactées, et seulement deux des treize répondants récupéraient la perte de chaleur des conduites de gaz des fours.

Un project demonstratif visant à encourager d'autres fonderies à bénéficier du programme de récupération de la perte de chaleur afin de réduire les dépenses énergétiques, est fortement à conseiller.

TABLE 1 - SUMMARY OF PROJECT COSTS AND POTENTIAL SAVINGS

(See Tables 3, 4 for details)

Present Fuel Costs for the Annealing Furnace = $335,000 per year

	OPTION**	TOTAL CAPITAL COST (including (Indirects*)	NET ANNUAL OPERATING SAVINGS	PAYBACK PERIOD
(A)	Central Recuperator Waste Heat Recovery with improved combustion control system	$276,100	$132,900 (40% of present fuel costs)	2.1 years
(B)	Regenerative Burners System for Waste Heat Recovery	$461,300	$156,300 (47% of present fuel costs)	3.0 years
(C)	Improved Furnace Controls (Alternative to A or B)	$210,000	$105,200 (31% of present fuel costs)	2.0 years
(D)	Insulation for Charge Door Curtains	$ 5,000	$ 10,200 (3% of present fuel costs)	0.5 years

PROJECT COSTS FOR OPTIONS "A" & "C":

		OPTION "A"	OPTION "C"
Detailed Engineering	=	$ 45,000	$ 37,500
Retrofit of equipment (material and labour), commissioning and owner acceptance	=	231,100	172,500
Sub-Total		276,100	210,000
Nine Month monitoring and maintenance	=	21,000	21,000
Total	=	$297,100	$231,000

* Indirects include Engineering, procurement, construction management, freight, insurance, temporary facilities, start-up.

** All these options are not additive. Options A - C include an allowance for insulation of charge door curtain (Option D).

1.0 INTRODUCTION

Hatch Associates were retained by Supply and Services Canada to provide a pre-evaluation of the potential for increasing the efficiency of oil and gas utilization in Foundries. The total cost of energy (coke not included) used in Canadian iron foundries alone in 1983 was $35.2 million*. The usage in the steel and non-ferrous foundries were additional to this. Improvements to reduce specific fuel consumption would result in significant savings for the Canadian Industry.

Stanton Pipes Ltd. was selected as the site for this study because some of the equipment was known to potentially require upgrading. The annual natural gas consumption is 130 million cf and no oil is used.

The scope of the study, as requested by DSS, has been to:

(a) Identify oil and gas burning industrial units at the site rated at 20 MMBTU/h or higher;

(b) Establish current performance on these units;

(c) Perform conceptual design work to improve fuel efficiencies;

(d) Briefly investigate the potential for application to other similar facilities in the country;

(e) Estimate capital, operating, engineering and other costs for detailed design, installation, start-up, 9 month monitoring and maintenance of the upgraded facility.

---

* From STATSCAN Catalogue No. 41-231.

2.0 DESCRIPTION OF CURRENT OPERATIONS

2.1 Products

Stanton Pipes Ltd., located in Hamilton, produces ductile (nodular) cast iron pressure pipes for water distribution systems. The pipe diameters range between 100 and 600 mm with lengths of 5.5 or 6 m. The current plant production is 23,000 tons/yr operating about 12 hrs/day, 5 days/week.

2.2 Melting and Casting

Melting is done in a cupola at a typical rate of 12 tons hot metal/hr. The operations and gas usage for the entire foundry are summarized in Fig.1. The air blast for the cupola is preheated to 650°F in a natural gas fired indirect heater and injected into the cupola through tuyeres near its bottom. The rating on this heater is about 10 MMBTU/h.

Natural gas is used for ladle heating, but the amount is relatively small (5% of annual total). The metal is cast into pipes in one of the three Centrifugal Casting Machines. A new horizontal casting machine for solid rounds was installed in March this year.

2.3 Annealing

The cast pipes are heated to a temperature of 1700 - 1800°F in a continuous annealing furnace. This furnace uses about 60% of the total annual natural gas consumption of the foundry. The rated capacity of the furnace is 24.4 MMBTU/h.

The pipes are transported through the furnace by a chain conveyor. The inner dimensions of the furnace are 72' length x 24' width x average 5.5' height. A schematic diagram of the furnace is given in Fig.2. The residence time for a pipe within the furnace is typically one hour.

The furnace length is divided into 3 zones:

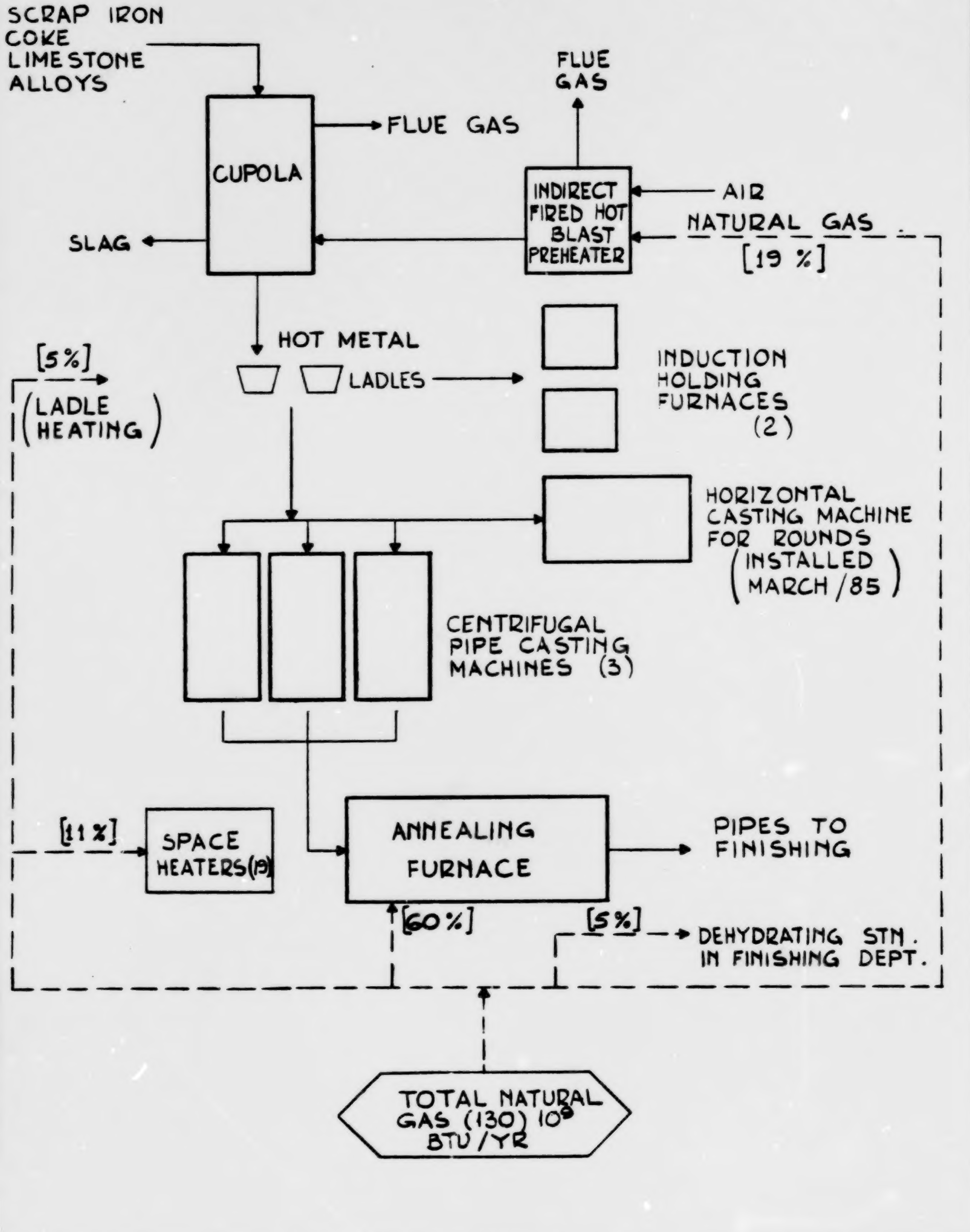
(1) A 22' long pre-heat zone which has 6 burners on each side with total capacity for both sides of 15 MMBTU/h;

(2) A 23' long soak zone which has 4 burners on each side of total capacity of 6.4 MMBTU/h; and

(3) A 27' long cooling zone which has 3 burners on each side of total capacity of about 3 MMBTU/h.

Heat transfer to the pipes in the pre-heat and soak zones is by radiation and convection.

The burners in the cooling zone are currently used only during start-up of the furnace. Fig.3(a) is a photograph of the side of the furnace looking towards the charge end. The blue piping is for combustion air, the yellow piping for natural gas.


SCRAP IRON
COKE
LIMESTONE
ALLOYS
CUPOLA
FLUE GAS
FLUE GAS
SLAG
INDIRECT FIRED HOT BLAST PREHEATER
AIR
NATURAL GAS
[19 %]
HOT METAL
LADLES
[5%]
(LADLE HEATING)
INDUCTION HOLDING FURNACES (2)
HORIZONTAL CASTING MACHINE FOR ROUNDS (INSTALLED MARCH/85)
CENTRIFUGAL PIPE CASTING MACHINES (3)
[11 %]
SPACE HEATERS(19)
ANNEALING FURNACE
PIPES TO FINISHING
[60 %]
[5%]
DEHYDRATING STN. IN FINISHING DEPT.
TOTAL NATURAL GAS (130) 10^9 BTU/YR

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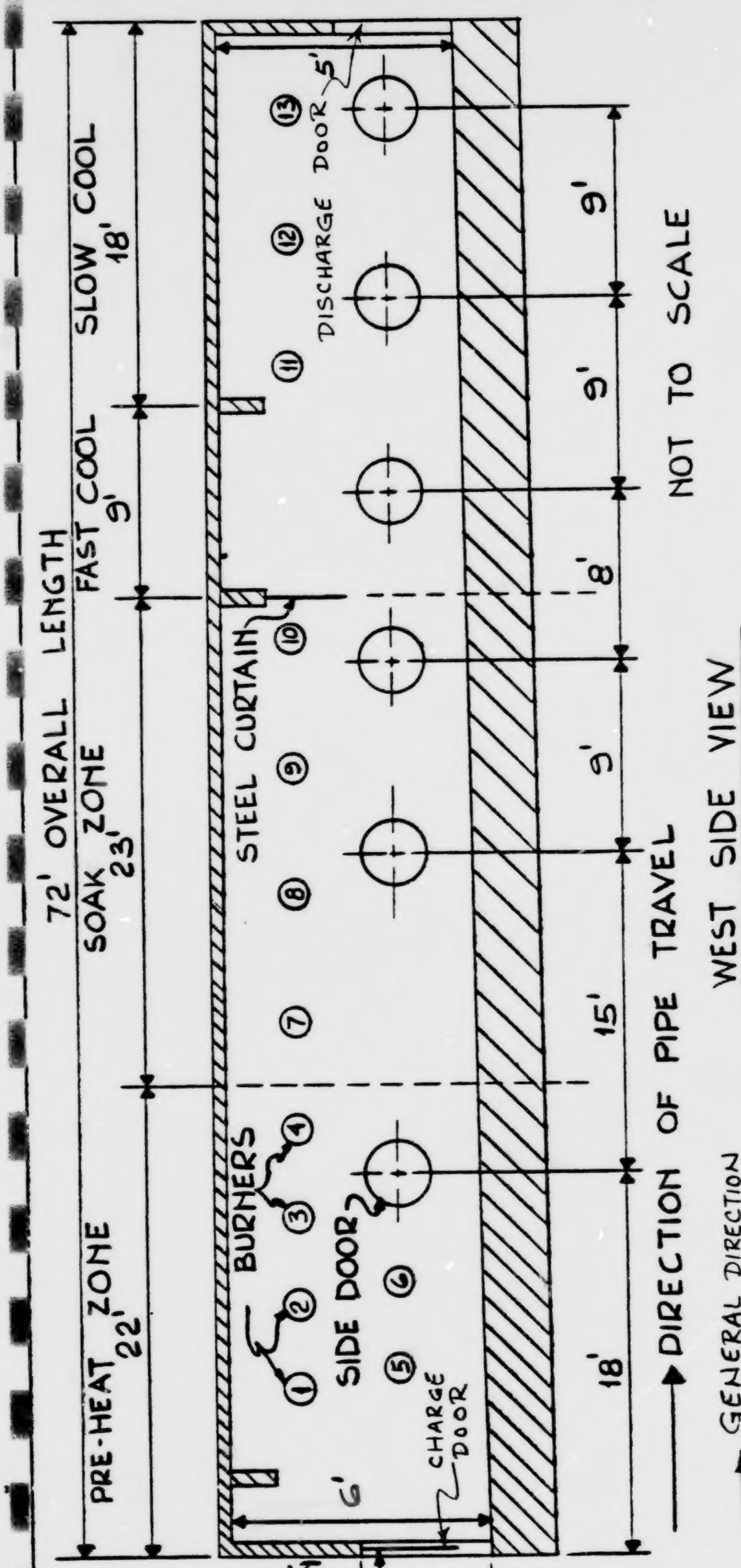
STANTON PIPES
OPERATIONS AND NATURAL GAS USAGE

FIG. NO. 1.


72' OVERALL LENGTH
PRE-HEAT ZONE 22'
SOAK ZONE 23'
FAST COOL 9'
SLOW COOL 18'
BURNERS
① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬
SIDE DOOR
STEEL CURTAIN
DISCHARGE DOOR
5'
CHARGE DOOR
6'
STEEL CURTAIN
3'
18'
15'
9'
8'
9'
9'
DIRECTION OF PIPE TRAVEL
GENERAL DIRECTION OF FLUE GAS FLOW

WEST SIDE VIEW

NOT TO SCALE

FURNACE WIDTH = 26' (OUTSIDE)
24' (INSIDE)

BURNER RATINGS

①	2.0 MMBTU/H EACH
② ③ ⑤ ⑥ ⑦ ⑧	1.0 MMBTU/H EACH
④	1.5 MMBTU/H EACH
⑨ ⑩ ⑪ ⑫	0.6 MMBTU/H EACH
⑬	0.34 MMBTU/H EACH

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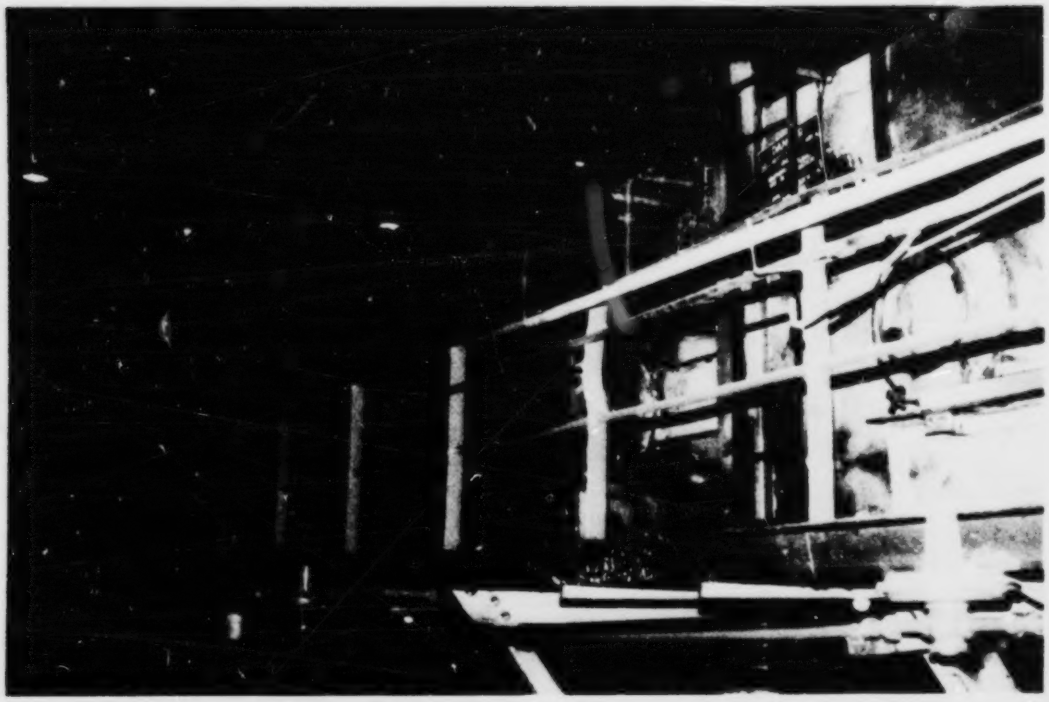
SCHEMATIC DRAWING OF ANNEALING FURNACE

FIG. NO. 2.



(a) SIDE VIEW

(b) CHARGE DOOR

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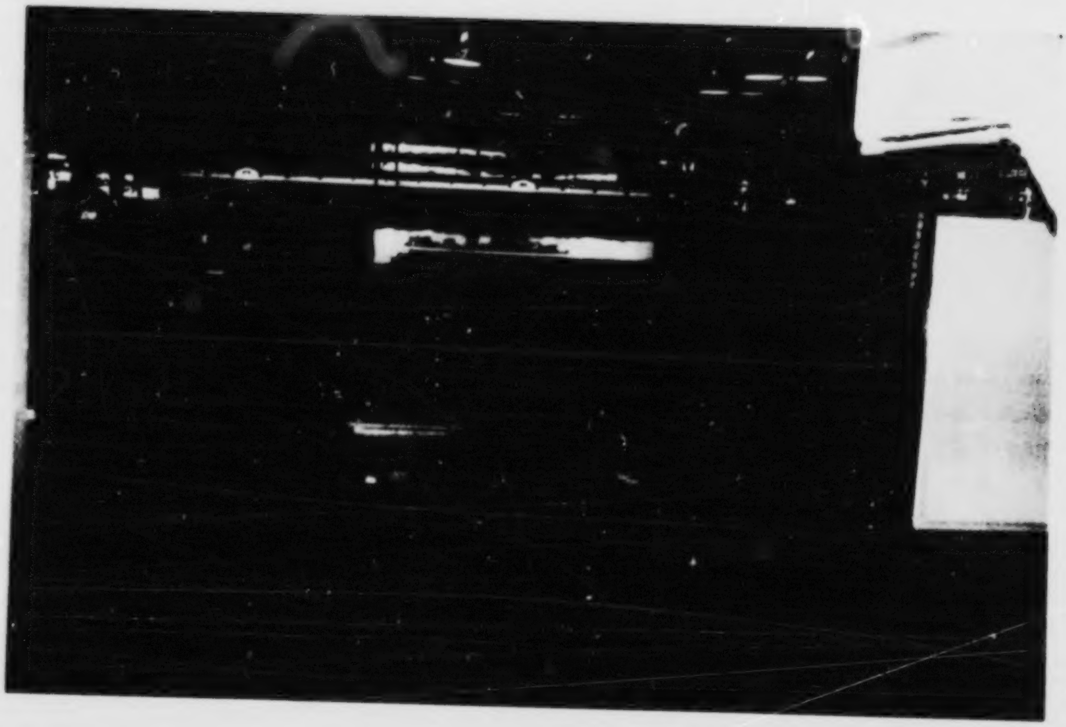
ANNEALING FURNACE

DWG. NO.

FIG. 3(a),(b)



(c) DISCHARGE DOOR

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ANNEALING FURNACE

DWG. NO.

FIG. 3(c)

2.3 Annealing (Cont'd)

The process requires that the pipes be soaked for at least 15 min. above a temperature of 1600°F, fast cooled and then slow cooled at a rate of about 20°F/hour so that the pipe temperature at the furnace exit is below 1350°F.

Waste gases consisting of products of combustion and infiltration air exhaust into the plant through furnace doors along the sides of the cooling zone and the discharge door (see Fig. 2). Axial fans above the discharge door of the furnace exhaust part of the waste gases into the finishing area for space heating. The gas temperature exiting the furnace was measured during field tests and is discussed in Section 3.2.

The open doors at the ends of the furnace are 24' wide x 3' high. Two parallel curtains of steel plates are located at the charge door to reduce radiation losses and infiltration air. They extend to within one foot of the furnace hearth (See Fig.3b). However, due to the wear on the plates at high temperatures, they break off and the curtain is not continuous. There is no curtain at the discharge end as the pipes are being cooled at this stage. There is also a curtain of steel plates (extending to 16" above the pipe support rail) between the soak and cooling zone to reduce heat losses and increase cooling rate. Fig.3(c) is a photograph of the discharge end of the furnace. The zone divider is essentially non-existent. A new curtain was put on shortly after the picture was taken (March 85).

The roof and top 18" of the sidewalls have 6" thickness of ceramic fibre (Fiberfrax) insulation with a steel outer shell. The rest of the sidewalls and hearth have about 15" brick refractory with a steel outer shell. The lower section of the sidewalls are sometimes hit by pipes which are misaligned within the conveyor. Consequently the ceramic fibre insulation was not installed along the entire sidewalls.

The burners on each side of a zone are controlled by a thermocouple on the opposite wall. The air input is varied to maintain the setpoint temperature by a set of motorized dampers. The fuel input is varied by a pressure regulator on the fuel line controlled by the air pressure downstream of the damper. A schematic diagram of the controls of the combustion system (based on field observations) is given in Appendix B. The bottom two burners on each side of the pre-heat zone are not directly controlled by a thermocouple. There is no regulating valve on the air line between these burners and the blower. Therefore the flow to the bottom burners is determined by the blower pressure and not the furnace temperature.

The only equipment at this foundry with a rating of over 20 MMBTU/h is the annealing furnace, therefore it was the only equipment examined for improving fuel utilization.

3.0 CURRENT PERFORMANCE OF ANNEALING FURNACE

3.1 Description of Field Tests Conducted

Field measurements were required to quantify the current energy flows.

The test program consisted of:

(1) Measuring the fuel consumption;

(2) Measuring the production rate of pipes through the annealing furnace, the inlet and outlet temperature for each pipe during the test period;

(3) Measuring the shell temperature of the furnace to allow calculation of shell heat losses;

(4) Estimating the flue gas velocity and temperature exiting the furnace. This was particularly difficult as the gases exhaust through the large 24' x 3' end door;

(5) Measuring the cooling water flowrate and temperature pick-up;

(6) Measuring the furnace and pipe temperatures in the different zones.

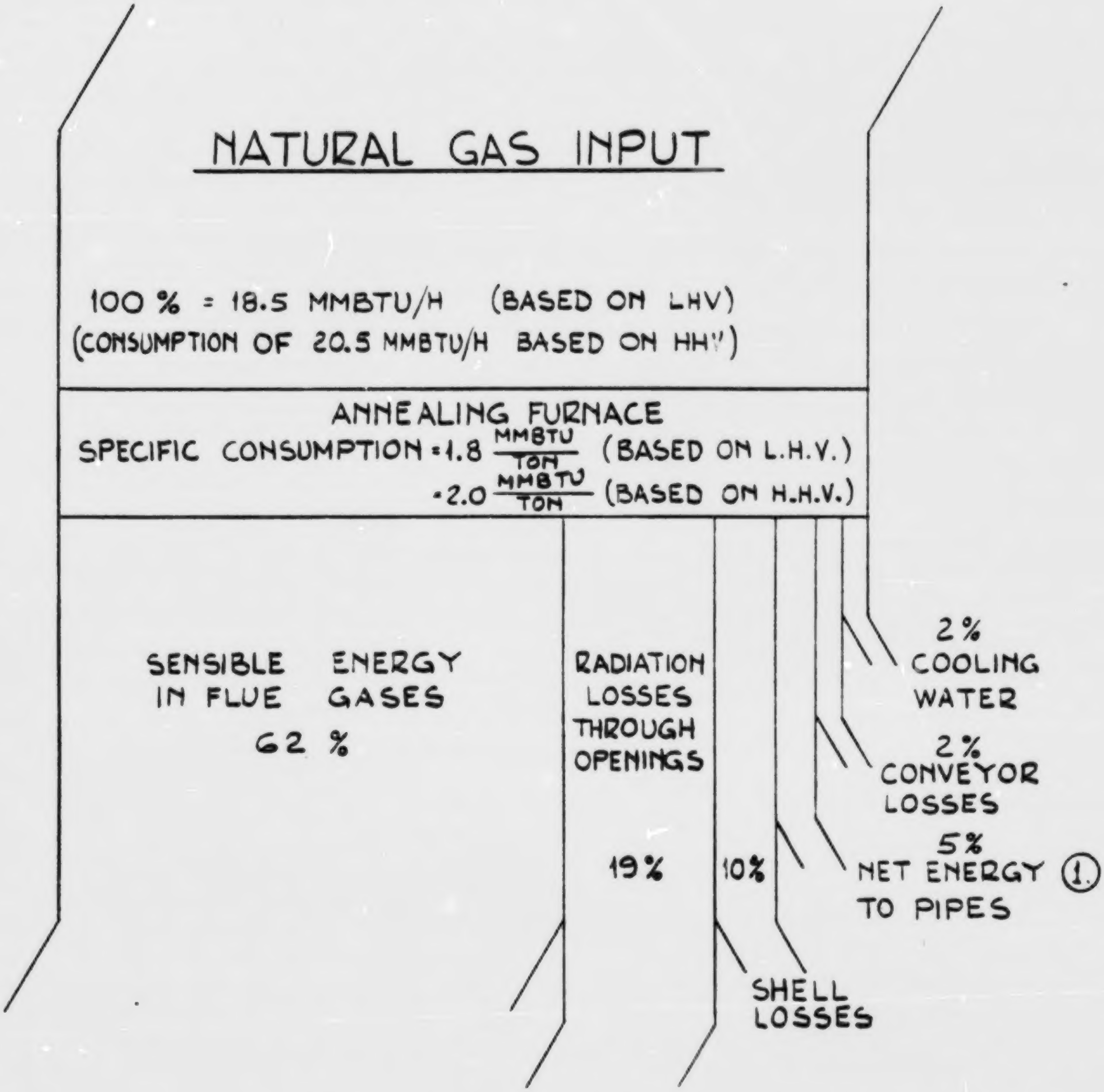
The fuel consumption during start-up of the furnace and start-up duration were also monitored.

3.2 Results of Field Tests

The fuel utilization is summarized in Fig.4. The complete data for the energy balance and the calculations are given in Appendix B.

The estimated total net energy output of 16.2 MMBTU/h (based on measurements) was in reasonable agreement with the measured fuel consumption of 18.5 MMBTU/h (based on LHV). As the fuel consumption was measured more accurately than the energy outputs, they were both taken to be 18.5 MMBTU/h. The total energy outflow was sub-divided between the different outputs in the same ratios as the original estimate. This was used as a basis in analyzing the energy conservation options discussed later.

The major energy losses are the waste heat in the flue gases at 1300°F and radiation losses through the ends. The plates at the charge door are limited in their effectiveness of reducing radiation losses since steel is a good conductor and the cold face is still quite hot (about 1100°F). Part of the radiation loss (in the cooling zone) is necessary to cool the


NATURAL GAS INPUT
100 % = 18.5 MMBTU/H (BASED ON LHV)
(CONSUMPTION OF 20.5 MMBTU/H BASED ON HHV)
ANNEALING FURNACE
SPECIFIC CONSUMPTION = 1.8 MMBTU/TON (BASED ON L.H.V.)
= 2.0 MMBTU/TON (BASED ON H.H.V.)
SENSIBLE ENERGY IN FLUE GASES
62 %
RADIATION LOSSES THROUGH OPENINGS
19 %
10%
SHELL LOSSES
5%
NET ENERGY ① TO PIPES
2 %
CONVEYOR LOSSES
2 %
COOLING WATER

NOTES:

1. TOTAL ENERGY PROVIDED TO PIPES TO HEAT IT TO 1800 °F IS 15 % OF GAS INPUT. PIPES EXIT THE FURNACE AT ABOUT 1300 °F.
2. THIS BALANCE EXCLUDES FURNACE DAILY HEAT-UP AND COOL-DOWN PERIODS.
3. ENERGY OUTPUT % BASED ON LHV.

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FUEL UTILIZATION OF
ANNEALING FURNACE

FIG. NO.
4.

3.2 Results of Field Tests (Cont'd)

pipes after soaking. The amount of energy required to heat pipes up to the soak temperature is only 15% of the energy in the fuel for an 1100°F pipe inlet temperature. The specific fuel consumption is 2.0 MMBTU/ton (based on HHV of fuel) excluding start-up.

The air: fuel ratio in the furnace could not be directly measured due to infiltration through the large furnace openings. Although the air infiltration could not be directly measured, most of it was through the charge door and some through the open side doors in the cooling zone. Based on fuel input and fuel gas volume, it is estimated that the total air entering the furnace (through burners and infiltration) is about 80% in excess of stoichiometric. The burners system is estimated to be operating at about 60% excess air. Air was observed to be entering through the charge door and open side doors in the cool zone. Flue gas exited primarily through the discharge door.

The hourly fuel consumption rate is not significantly affected by the normal variation in production rate because only a small portion of the energy goes to the pipes.

The fuel consumption for heat-up of the furnace is estimated at 23 MMBTU over a period of one hour, once per operating day. The resulting specific consumption based on a operating day is about 2.2 MMBTU/h (based on HHV).

3.3 Stanton's Measurements of Burner Settings

The gas and air pressure settings on each of the burners were measured by Stanton personnel using a dial manometer. These were taken during a different period than the measurements discussed previously. The measurements are summarized in Table 2. Also listed are the manufacturer's specifications for the burner settings at rated capacity. Several points may be noted:

(a) The actual firing rate of the two walls of burners is not symmetrical. However, the weight distribution at the two ends of the product pipes is also not symmetrical. Each pipe has a socket which fits into the adjacent pipe in construction. This socket has a higher weight (by at least 100%) per foot length of the pipe than the rest of the pipe. The weight of the socket is 4-5% of the total pipe's weight. One may expect that the side of the furnace on which the sockets are, the west side, may have a slightly higher firing rate. However, this is not consistently observed and therefore the lack of symmetry in burner firing rates is not due to the sockets. There is no specific control strategy on how to optimize the firing rates of the burners in a zone;

TABLE 2

AIR AND GAS PRESSURE SETTINGS AT BURNERS

Burner Location (as per Fig 2)	Model No.	Manufacturer's specifications at rated capacity		Field Measurements			
				West Side		East Side	
		Gas	Air	Gas	Air	Gas	Air
1	1460-040	4"W.C.	7"W.C	3.9"W.C.	2.8"W.C.	(NOT)	1.0"W.C.
2	1460-035	2.9	7	9.5	11.0	(MEASURED)	11.8
3	351L	N/A	7	5.1	9.5	4.0	11.8
4	401L	N/A	7	4.0	6.0	2.5	8.5
5	301 HTR	20	28	19.1	28.1	(TYPICALLY)	
6	301 HTR	20	28	24.9	26.8	(OFF)	
7	351L	N/A	7	4.0	5.5	4.2	11.0
8	351L	N/A	7	4.1	5.9	5.5	11.0
9	301L	2.7	7	(NOT)		8.0	4.1
10	301L	2.7	7	(MEASURED)		NOT MEASURED	4.2
11	175-1-3	1.1	3.25				
12	175-1-3	1.1	3.25	(USUALLY OFF)			
13	175-1-2.5	1.1	3.25				

3.3 Stanton's Measurements of Burner Settings (Cont'd)

(b) For the first top two burners in the west pre-heat zone, the gas pressure is above or close to the air pressure, Comparison with the manufacturer's specifications indicates that the mixture is likely very rich;

(c) The first top burner on both walls of the pre-heat zone is on low fire whereas the adjacent burner is on high fire. This is undesirable as large amounts of excess air are usually required during low fire conditions;

Some of the pipes for the pilot are partly burnt out and gas leaks into the area around the furnace.

4.0 OVERVIEW OF CURRENT TECHNOLOGY FOR REDUCTION OF ENERGY CONSUMPTION

4.1 Introduction

Several methods have been developed to improve the energy efficiency of heat treating and reheating furnaces. Most can be classified under one or more of the following:

(a) Off-gas waste heat recovery;
(b) Reduction of heat losses from furnace shell, doors and cooling water;
(c) Improved furnace control; and
(d) Improved Production scheduling.

Each of these is discussed below.

4.2 Off-Gas Waste Heat Recovery

As seen from Fig 4, the off-gas carries away a significant portion of the energy in the fuel (about 62%, based on LHV, of the fuel input at Stanton). A waste heat recuperator for combustion air preheating is common on modern furnaces. The off-gas duct is located at the charge end of the furnace to allow conterflow heat transfer between the gases and the product within the furnace. The waste heat can also be used to produce hot water or steam for plant use.

Recuperative burners which exhaust the flue gases back through the burner to preheat the combustion air at the burner are now available. They eliminate the need for insulated air piping and an off-gas duct on the furnace.

A new type of burner which also preheats air and is just becoming available is the regenerative burner. It actually consists of two burners which alternate as to which burns fuel at any one time. The flue gases exhaust through the burner which is off to heat a ceramic regenerator. This in turn preheats the combustion air when the burners switch modes of operation. Literature on these two types of burners is included in Appendix C.

Oxygen enrichment of the combustion air reduces the quantity of flue gas and therefore the off-gas losses. It also results in higher heat transfer rates due to higher flame temperatures. However, the materials within the furnace must be able to withstand the higher temperatures.

In systems where the off-gas is collected and its direction of flow controlled, more waste heat can be recovered by the use of an unfired preheat zone. This zone allows time for heat transfer from the combustion gases to the product.

4.3 Reduction of Losses from Furnace and Cooling Water

At Stanton, losses from the furnace and cooling water account for about 31% of the fuel input. Replacement of part of furnace refractory with ceramic fibre insulation of lower heat capacity results in shorter heat-up periods and lower energy consumption for heat-up. Ceramic insulation also reduces heat loss over non-insulating refractory during operation due to its lower thermal conductivity.

Radiation from the ends of the furnace are a major source of heat loss. End doors which are synchronized to open with the movement of the stock have been used. The lifting velocity of systems commonly available is restricted to about 1"/sec. These doors also reduce air infiltration, and hence the off-gas waste heat losses.

Curtains may be used in applications where doors are not practical. Curtains of steel plates and/or ceramic fibre have been successfully used.

Some plants recover sensible heat from the heated product by producing steam. This can be achieved by running water through cooling panels which surround the product after it exits from the furnace. The water picks up heat from the products as it cools. This also gives better control of the cooling.

The cooling water losses can be reduced by insulation of the water pipes. Double insulation has been used on many furnaces. The hot water or steam which is produced from the water cooled pipes can be used within the plant.

4.4 Improved Furnace Control

Fuel consumption can be significantly reduced by proper burner control. These include maintaining an air: fuel ratio close to stoichiometric. Many furnaces have a cascade control system for the burners whereby banks of burners are shut-off automatically at low throughput rates. This eliminates the need for large excess air on some burners when operating at low firing rates.

There is a growing trend, particularly in Europe and Japan, towards the use of on-line computer control. Simple microprocessor systems control the burners to maintain temperature set-points of furnace zones. Direct control systems use mathematical models to control the heat input. The models simulate the heating process and calculate a furnace heat input configuration for a given stock before it is charged to minimize fuel consumption and meet process constraints, i.e. it is not a reactive but a feed-forward control system.

4.5 Improved Production Scheduling

Any operational changes which reduce delays, stand-by periods or increase the product temperature entering the furnace will improve the fuel utilization.

5.0 ANALYSIS OF OPTIONS FOR REDUCING SPECIFIC FUEL CONSUMPTION AT STANTON

5.1 Overview of Options

Based on the measured energy flows, the following are major areas for improving fuel utilization:

(a) Waste Heat Recovery from the flue gas. The heat could be used for combustion air preheating at the furnace, cupola blast air preheating or space heaters. Its use at the annealing furnace is preferred since the duct run will be shorter, and the availability of the heat will better match the requirement (the operating times for the furnace and cupola vary slightly).

The possibility does exist of a two-stage heat recovery: first stage to be combustion air preheating with the second stage being the cupola hot blast preheat. However, this will not be the most economic option. The amount used for space heating is small and is required for only part of the year. Therefore it will also not be the most economic option.

Use of the waste heat at a location other than the furnace has the additional problem of a very difficult routing for the duct. For these reasons, the waste heat recovery options examined are based on combustion air preheating at the furnace only.

(b) Improved furnace control to reduce excess air and provide good heat distribution.

(c) Reduced radiation heat losses from end doors and air infiltration at the charge end of the furnace. The velocity of the commonly used movable end doors are far too slow to be of application here.

(d) Further use of ceramic fibre insulation in the furnace.

(e) Increased furnace production rate to reduce the time for the required run and increase the pipe temperature entering the furnace. This could be achieved by increasing the cooling rate.

Each of these options is discussed separately below.

Stanton has used oxygen enrichment of combustion air in the past, but have found the cost to be prohibitive. It is currently not used.

5.1 Overview of Optionse (Cont'd)

The concept of an unfired preheating zone or extending the furnace length to allow a greater heating or cooling rate to increase production may be desirable. However since its main advantage is productivity rather than energy usage improvement, it fell outside the scope of the study and was not examined further.

The following energy costs, as given by Stanton were used in the analysis:

Natural Gas:	$4.30/10^3$ SCF
Electricity:	$0.03/kW-h

5.2 Off-Gas Waste Heat Recovery

The fuel consumption can be reduced significantly by recovering heat from the waste gases. This may be achieved by different methods as discussed below.

Each of these options will also significantly reduce the quantity of flue gases in the cooling zone where heat is not required during production. This will reduce the temperature in this zone thus reducing the shell losses and improving the cooling rate of the pipes. These additional benefits have not been included in the estimate of operating savings, but they will reduce the payback period.

5.2.1 Central Recuperator

The common arrangement is to use a single recuperator for combustion air preheating. For the Stanton site, this would require:

(a) A stainless steel plate heat exchanger.

(b) A flue gas duct from the furnace to the recuperator and then to an exhaust.

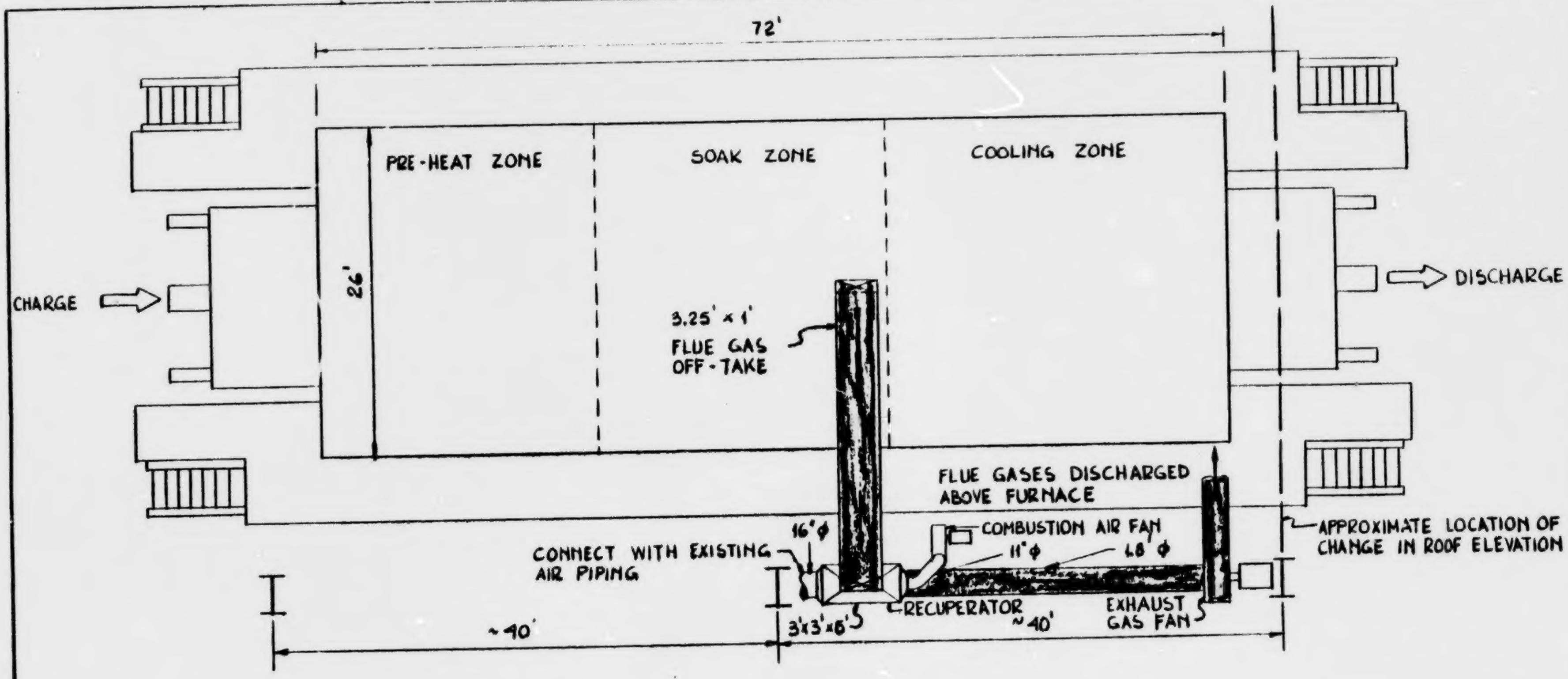
(c) A hot gas fan for the flue gas.

(d) New blower(s) for combustion air.

(e) New insulated combustion air piping and controls to handle the preheated air. It is being assumed that the existing valves and regulators will be inadequate.

A schematic layout for this option is given in Figure 5.

The flue gases would be exhausted from the furnace roof at the end of the soak zone. This will minimize any ambient air from the discharge and side doors entering the exhaust duct. An offtake at the side of the furnace would likely reduce the


72'
PRE-HEAT ZONE
SOAK ZONE
COOLING ZONE
26'
CHARGE
DISCHARGE
3.25' × 1'
FLUE GAS
OFF-TAKE
FLUE GASES DISCHARGED
ABOVE FURNACE
APPROXIMATE LOCATION OF
CHANGE IN ROOF ELEVATION
16' φ
CONNECT WITH EXISTING
AIR PIPING
COMBUSTION AIR FAN
11' φ
6.8' φ
RECUPERATOR
3'x3'x6'
~40'
EXHAUST
GAS FAN
~40'

PLAN VIEW OF FURNACE

CONCEPTUAL LAYOUT FOR
CENTRAL RECUPERATOR

FIG. NO.
5.

DESIGNED BY S.K.
DATE APR/85
DISCIPL. ENGR.
DATE
PROJ ENGR.
DATE

HATCH ASSOCIATES LTD.
CONSULTING ENGINEERS

DWG. NO.

5.2.1 Central Recuperator (Cont'd)

uniformity of pipe temperature and is undesirable. The duct would be brought to a recuperator (estimated size including casing approximately 5' X 3' X 3') and then to a hot gas fan west of the furnace. The flue gases would be exhausted above the furnace discharge door and would be drawn by the axial fans into the finishing area as at present. The clearance available for the duct above the furnace is restricted to 2-3 ft. by the crane movement.

An offtake near the charge door would result in the flue gases moving in an opposite direction to the pipes. This would increase the convective heat transfer rate, but may increase the infiltration through the charge door and reduce the heat transfer from the products of combustion from the higher capacity burners near the charge end due to flow short circuiting. At the detailed engineering stage, this along with other layouts for the duct offtake should be examined to maximize the energy savings within the available space.

The recuperator, a plate type heat exchanger, would preheat the combustion air to about 600°F - the temperature limit for the current burners. The flue gases would enter the recuperator at about 1300°F and exit at a relatively high temperature of about 900°F.

New blower(s) will likely be required for the combustion air due to the change in flows and pressure drops in the system.

It is being assumed that most of the existing combustion air piping can be re-used but will require about 3" insulation. If all the piping has to be replaced, it would result in an additional total cost of about $20,000. This is not included in the analysis.

Major changes will also be required in the control system. With pre-heated air, the current pressure based system for air: fuel ratio control will not work. The control valves and regulators will likely be unable to withstand the higher temperatures. The control must be based on mass rather that volumetric flow ratios, as the air pre-heat temperature may vary. It is being assumed that the air: fuel ratio at the burners can be reduced to 12:1 (equivalent to 26% excess air). The total fuel savings for this option is about $137,700, over 75% of which is due to a reduction in air entering the furnace.

The estimated capital costs and operating savings are summarized in Table 3 with the details given in Appendix D. The total capital cost including indirects and contingencies is estimated at $276,100. The resultant payback period is 2.1 years.

5.2.2 Self-Recuperative Burners

This option would require replacement of the 20 burners in the pre-heat and soak zones with new recuperative burners. Recuperative burners would not be installed in the cooling zone as the burners in this zone are used only for start-up. These burners can provide an air preheat temperature of about 600 °F (the same as before) for the temperature of the exhaust gases at Stanton.

The exhaust gases would be drawn into the burner using an eductor. The cooled flue gases could be exhausted directly above the furnace and used in the finishing area. A new combustion air blower and eductor fan will be required.

The total capital costs (see Table 3) are estimated at $573,000, the payback on the system would be 4.4 years (see Appendix E for details). The costs for the burners and combustion controls provided by the manufacturer are preliminary only and may change upon detailed review of the requirements.

5.2.3 Regenerative Burners

The regenerative burners offer a much higher air preheat temperature. With an exhaust temperature of 1800°F, the typical air preheat temperature would be 1700°F. The exhaust flue gas would be about 400°F.

With the burners manufactured by Regen Systems Inc. (developed by British Gas) the furnace would be operated at a slight positive pressure with a high recirculating flow (about 6:1) achieved by geometrical arrangement to provide mixing. The cycle time for a pair of these burners is between 30 seconds - 3 minutes. A fan rather than an eductor is recommended by the manufacturer for exhausting the flue gases. The burners connected in pairs would be across from each other (but slightly offset) on opposite sidewalls. The control strategy as to how many burners would switch mode of operation at the same time would be finalized at the detailed design stage, but this will have insignificant impact on the costs.

Since the heat in the flue gases exhausted will be significantly lower than at present, an additional space heater may be required in the finishing area. This has not specifically been allowed for in the cost estimates.

The order of magnitude cost for the Regen system for the Stanton furnace would be about $487,500 (see Table 3 and Appendix G). The payback for this system would be about 3.1 years.

TABLE 3 - SUMMARY OF COSTS FOR WASTE HEAT RECOVERY OPTIONS

ITEM	OPTION CENTRAL RECUPERATOR	SELF RECUPERATIVE BURNERS	REGENERATIVE BURNERS - "REGEN" TYPE	REGENERATIVE BURNERS - "NORTH AMERICAN" TYPE
Heat Exchanger	$28,000	-	-	-
Combustion Air Fan	7,500	$ 7,500	$325,000 (break-down not provided by manufacturer)	$ 7,500
Exhaust Gas Fan	50,000 (high temperature fan)	Eductor - 50,000		25,000
Combustion Air Piping	4,600	-		-
Insulation for Air Piping	7,600	-		-
Exhaust Gas Ducting	$21,200 (mild steel shell) + $10,200 (insulating refractory) = 31,400	Eductor Piping - 15,000		25,000
Combustion Controls (valves, regulators, controllers)	55,000	65,000		65,000
Burners	-	235,000		185,000
Total Direct Costs *	184,100	382,500	325,000	307,500
Indirect Costs** + Contingencies (at 50%)	92,000	191,300	162,500	153,800
TOTAL CAPITAL COSTS	276,100	573,800	487,500	461,300
Annual Operating Savings:				
Fuel	137,700	137,700	162,500	162,500
Fan Power	700	0	0	0
Maintenance***	-5,500	-8,500	-6,200	-6,200
NET ANNUAL OPERATING SAVINGS	132,900	129,200	156,300	156,300
Payback Period	2.1 Years	4.4 Years	3.1 Years	3.0 Years

* All direct costs include labour, supports, electrics and control unless noted otherwise.

** Indirect costs include detailed engineering, procurement, construction management, freight, insurance, temporary facilities, start-up.

*** Taken at (3% of Direct Costs - allowance for existing equipment to be replaced)

5.2.3 Regenerative Burners (Cont'd)

The North American Manufacturing Company markets a similar type of regenerative burner. The estimated costs are listed in Table 3. The total capital cost is about $461,300, insignificantly different from the cost for the Regen system.

5.3 Improved Furnace Control

The waste heat recovery options discussed above have included improving the combustion controls. A new burner control system (sensors, controller, valves) with routine maintenance of all components should by itself significantly reduce the excess air supplied through the burners and is an alternative to the waste heat recovery options.

In addition, an exhaust gas system could be installed to control the furnace pressure and minimize air infiltration. As for the central recuperator option, several possible locations exist for withdrawing the gases. Alternative layouts should be analyzed at the detailed engineering stage.

Due to the "eductor" action of the burners, under present operation, which draw in cold air through the charge door, it is difficult to determine if control of the furnace pressure (by an exhaust gas system) would significantly reduce this air infiltration. An exhaust gas system could be installed as a second phase after monitoring the impact of improved combustion controls.

For the present analysis, it has been assumed that an exhaust gas system in addition to the combustion controls will be required. This additional cost significantly reduces the payback.

The costs for this option (see Appendix G for calculations are summarized below:

Combustion Controls	$ 55,000
Exhaust Gas Fan	50,000
Exhaust Gas Ducting	35,000
Total Direct Costs	$140,000
Indirect Costs + Contingencies (at 50%)	70,000
TOTAL CAPITAL COSTS	210,000
Annual Operating Savings:	
Fuel	108,700
Fan Power	700
Maintenance	-4,200
NET ANNUAL OPERATING SAVINGS	105,200
Payback Period =	2.0 years

5.4 Reduced Heat Losses From End Doors

An improved curtain at the charge door would significantly improve the fuel utilization. Calculations indicate that the losses at the charge door for a single layer of steel curtain is about 12,800 BTU/h-ft^2. With 1/4" of Fiberfrax type ceramic fibre insulation on the steel plate, the losses can be reduced to 2,200 BTU/h-ft^2 (see Appendix H for calculations).

The annual savings would be:

Installed Cost for a ¼" thick layer insulation	= $ 5,000
Annual Fuel savings over current operation	= $10,200
Payback Period	= 6 Months

The insulation will also increase the life of the steel curtain, resulting in a faster payback.

The insulation should not be used without a steel plate because:

(a) the insulation has a tendency to curl due to differential thermal expansion on the two faces

(b) the insulation does not have good resistance to abrasive contact.

Two layers of steel plates with a layer of insulation in between could be used. It would provide greater strength and help to keep the insulation in place. However, the metal temperature on the hot side will be higher and the life may be reduced.

The existing steel curtain between the soak and cooling zones is partly effective in reducing the temperature in the cooling zone and the losses to outside. The soaking zone temperature could be further reduced by using an insulating material for the divider. The insulation for the charge door discussed above should also be used for the zone divider. Another product which has been used for this application is the Nextel fiber manufactured by 3M. It can be used for temperatures upto 2600°F but does not have good mechanical resistance. Typically, two layers of 0.058" thickness material are used with a layer of insulation to provide structural rigidity in between. It should be feasible to apply this material to a steel plate. The fiber alone could be used if the curtain was short enough to clear the pipes, however the opening between the zones would be larger and the curtain would not be very effective.

5.5 Further Use of Ceramic Fibre Insulation

Since most of the furnace already has ceramic fibre insulation, there is little opportunity for further use. The lower sidewalls must be refractory on the inside due to possible contact with pipes. Insulation could be added on the outside but there would be no overall economic benefits.

The refractory currently in the hearth is a good insulator (outer shell temperature - 150°F). The heat-up period could be reduced by replacing the refractory with ceramic fibre. However, the presence of the conveying system along the hearth will make this replacement uneconomic. Some benefits would be obtained by insulating the cooling water channels.

During a visit to the plant it was observed that part of the furnace roof had "collapsed". This may be due to:

(a) insufficient thickness of the insulation originally installed

(b) part of the insulation of the inside of the the furnace falling off

(c) unusually high furnace termperature in that area.

Impact from any object was highly unlikely.

An inspection of the roof when the furnace is off should reveal if the problem is local. If the entire roof is overheating, further insulation will be required for the entire roof.

Visual inspections should be frequently conducted of the insulation within the furnace. Any fallen off insulation should be re-attached to the roof or replaced.

An unusually high furnace temperature indicates poor combustion control and corrective measures would have to focus on this.

5.6 Increased Furnace Throughput

An increased furnace production rate can be obtained by reducing the temperature in the cooling zone. The lower temperature then allows a faster conveyor speed to achieve the required time temperature relationship. This would result in a shorter production time for a given total production or higher production for the same time, both giving a reduced specific fuel consumption. Turning on the air for the burners in the cooling zone may increase the cooling rate. A similar practice is used at another foundry.

Improvements to the zone divider, as discussed previously will also increase production rate.

5.7 Summary of Project Costs

The project costs for the central recuperator waste heat recovery option and improved furnace controls option (the two options with the best indicated payback) are outlined in Table 4. Although the paybacks are approximately the same, the net operating savings for the waste heat recovery option is higher.

TABLE 4 - SUMMARY OF PROJECT COSTS

	ALTERNATIVE OPTIONS	
(a) DETAILED ENGINEERING:	CENTRAL RECUPERATOR WASTE HEAT RECOVERY	IMPROVED FURNACE CONTROLS OPTION
Drawings (including design)	\$30,000 (2 general arrangements) (2 piping details) (2 instrumentation)	\$25,000 (2 general arrangements) (1 piping detail) (2 instrumentation)
Specifications and Bid Analysis	\$10,000 - Recuperator - Controls - Blowers, Fans	\$ 7,500 (controls, fan)
TOTAL	Allow \$45,000 including expenses	Allow \$37,500 including expenses
(b) RETROFIT OF EQUIPMENT COMMISSIONING AND OWNER ACCEPTANCE		
Material, Labour, Contingencies,	\$216,000	\$161,300
Procurement, Commissioning Start-up (8% of Total Direct Costs)	\$ 15,000	\$ 11,200
TOTAL	\$231,000	\$172,500
TOTAL (a) and (b) =	\$276,100	\$210,000
(c) NINE-MONTH MONITORING AND MAINTENANCE		
Maintenance (Taken at 3% of Total Direct Costs - allowance for current equipment to be replaced)	\$ 5,500	5,500
Monitoring:		
Dedicated gas meter for the furnace with continuous recorder	6,000	6,000
Monthly Data Reporting	2,000	2,000
Inspections of Combustion Control Systems	1,500	1,500
Two sets of Field measurements to evaluate furnace performance along with data analysis	2,000	2,000
Final Monitoring Report	4,000	4,000
TOTAL FOR THIS PHASE	\$21,000	\$21,000
TOTAL (a) + (b) + (c)	\$297,100	\$231,000

6.0 POTENTIAL FOR APPLICATION TO OTHER FOUNDRIES

6.1 Objectives

A brief survey was conducted of the potential for application of the energy saving measures discussed in Section 5 to other Canadian foundries. The primary objectives were to determine the number and size of facilities where these concepts may also be applicable. It was beyond the scope to establish any capital costs or operating savings.

6.2 Methodology of Survey

A total of 22 of the larger ferrous and non-ferrous foundries were contacted by phone and/or mail. Collectively their production equals 83,610 tons per month. The current total Canadian foundry production is estimated to be in the order of 120,000 TPM. Therefore this sample represents about 70% of the total. The sample is by no means a comprehensive survey of all Canadian foundries, but does represent a significant portion of the total production. Due to higher operating rates and higher fuel consumptions, the larger foundries are more likely to implement energy conservation projects.

For each site, a questionnaire on their operation and oil/gas users was completed. The questionaire requested:

(1) Basic data on the company and its products.

(2) Data on the major oil and gas users (and typical consumption where available).

(3) Description of any heat treat furnaces (flue gas system, insulation, burner controls, etc.)

In many cases, the information requested was not available or could not be made available for confidentiality reasons.

6.3 Results and Conclusions

A summary of the results is presented in Table 5. Completed questionnaires for each site are included in Appendix I. The actual tons of metal processed may be higher than the listed production due to metal recycles.

The following conclusions from Table 5 are worthy of note:

(a) The majority of foundries surveyed do have heat treatment furnaces (65% of those responding).

6.3 Results and Conclusions (Cont'd)

(b) Only 2 of the 13 foundries with heat treatment furnaces make use of the waste heat in the flue gases. Therefore there is a tremendous potential for application of this in Canadian foundries.

(c) Most furnaces do have an air/fuel ratio controller for the burners. However, many of these may not be working very well.

(d) Most of the plant personnel contacted feel that the level of insulation and condition of seals on their furnace are quite good. However, the responses were qualitative, therefore there may be different standards of evaluation and potential may exist for further reduction of fuel consumption by improving insulation and seals.

(e) None of the plants contacted could provide a figure for specific fuel consumption at the heat treat furnace(s). The fuel consumption at the furnace is not continuously monitored at most foundries and in several cases it is not even known. These illustrate the low priority given to energy consumption in operating the furnaces. Based on the data obtained, the specific fuel consumption at some furnaces is as high as 7.5 MMBTU/ton.

Assuming: (a) Total throughput in all heat treatment furnaces in Canadian foundries = 60,000 TPM (half of total foundry production)

(b) Average Cost of Fuel = $4.5/MMBTU

(c) Average energy savings at heat treatment furnace = 1.0 MMBTU/ton

Total Potential Savings in Heat Treatment Furnaces
= 60,000 x 12 x 4.5 x 1.0 = $3.2 million per year

TABLE 5 - SUMMARY OF SURVEY OF HEAT TREATMENT FURNACE OPERATION IN FOUNDRIES

					HEAT TREATMENT FURNACES				
FOUNDRY	CURRENT PRODUCTION (TPM)	METALS PROCESSED	PRIMARY FUEL(S)	HAVE HEAT TREATMENT FACILITIES	TYPE OF FURNACE(S)	HAVE FLUE GAS WASTE HEAT RECOVERY	HAVE AIR: FUEL RATIO CONTROL	USE OF CERAMIC FIBRE INSULATION	CONDITION OF FURNACE SEALS
A-1 Steel, Saskatoon	100	Iron, Steel	Natural Gas (NG)	Yes - 1 Fce.	Car - Bottom	No	Yes	No	Good
Abex, Joliette	600	Steel	Oil, NG	Yes - 5 Fces.	Car - Bottom	No	Yes	Partial	Good
Abex, Selkirk	300	Iron, Steel	NG	Yes - 3 Fces.	Car - Bottom	No	*	*	*
Canadian Steel Foundries, Montreal	2100	Steel	NG	Yes - 15 Fces.	Car - Bottom	No	Yes - Manual Adjustment of Air and Fuel	Partial	Good
Canron - Foundry Division, Hamilton	9600	Iron	NG	No	-	-	-	-	-
Canron - Pipe Division, Toronto	2500	Iron	NG	Yes - 1 Fce.	Continuous	No	No	Yes	Poor
Cleveland - CAE Metal Abrasive, Welland	Estimated at 1500	Steel		Yes	No Response Received				
Crane, Brantford	360	Brass	NG	No	-	-	-	-	-
Dayton-Walther, Guelph	1500	Iron, Ste.	NG	Yes - 1 Fce.	Continuous	Yes - Heating Plant Air	Yes	Yes	Very Poor
Dofasco Inc., Hamilton	Estimated at 3500	Steel	NG	Yes	No Response Received				
Esco, Port Coquitlam	800	Steel	NG	Yes - 3 Fces.	Car - Bottom	No	Yes	Yes	Good
Fahramet, Orillia	400	Steel	NG	Yes - 4 Fces.	Car - Bottom	No	Yes	Partial	Good
Fonderie Ste.Croix, Ste. Croix	2000	Iron	NG	No	-	-	-	-	-

* Information could not be obtained.

TABLE 5 (Cont'd) - SUMMARY OF SURVEY OF HEAT TREATMENT FURNACE OPERATION IN FOUNDRIES

					HEAT TREATMENT FURNACES				
FOUNDRY	CURRENT PRODUCTION (TPM)	METALS PROCESSED	PRIMARY FUEL(S)	HAVE HEAT TREATMENT FACILITIES	TYPE OF FURNACE(S)	HAVE FLUE GAS WASTE HEAT RECOVERY	HAVE AIR: FUEL RATIO CONTROL	USE OF CERAMIC FIBRE INSULATION	CONDITION OF FURNACE SEALS
Ford Motor Co., Windsor Aluminum Casting Plant	4500	Aluminum	NG	No	-	-	- Adjustment of Air and Fuel	-	-
Ford Motor Co., Windsor Iron Casting Plant	12000	Iron	NG	Yes - 2 Fces.	Continuous	No	Yes - Manual	Yes	Good
General Motors, St. Catherines	30000	Iron	NG	Yes - 2 Fces.	Continuous	No	Yes	*	Poor on one & Good on other
Griffin, St. Hyacinthe	1750	Steel	Oil	Yes - 1 Fce.	Continuous	No	Yes	No	Poor
Griffin, Winnipeg	Confidential (Estimated at 3500)	Steel	NG	Yes - 3 Fces.	Continuous	On one Fce. for preheating Combustion Air	Yes	*	Good
ITT Aimco, St. Catherines	4000	Iron	NG	No	-	-	-	-	-
Maritime Steel & Foundries, New Glasgow	150	Steel	Oil	Yes - 3 Fces.	Car - Bottom	No	Yes - Manual	Yes	Good
McCoy Foundries, Troy	1350	Iron	Converting to Natural Gas from oil	No	-	-	-	-	-
Sysco, Sydney	1000	Iron, Steel	Propane	No	-	-	-	-	-
TOTALS	All Foundries in Survey = 83,610 Foundries Responding = 78,610	-	-	13 of 20 (65%) Foundries responding have heat treatment facilities.	Car-bottom: 7 Continuous: 6	Yes: 2 No: 11	Yes: 12 No: 1	Incomplete Data	

* Information could not be obtained.

LIST OF APPENDICES

A	Summary of Natural Gas Uses in Stanton Foundry
B	Field Data and Analysis
C	Literature on Recuperative and Regenerative Burners
D	General Notes on Method for Cost Estimates and Analysis for Central Recuperator Option
E	Analysis for Self-Recuperative Burners Option
F	Analysis for Regenerative Burners Option
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H	Analysis for Improved Radiation Shields Option
I	Completed Questionnaires from Survey on Fuel Usage

APPENDIX A

SUMMARY OF NATURAL GAS USES AT THE STANTON PIPES FOUNDRY

CONTENTS :

	PAGES
• LIST OF EQUIPMENT USING NATURAL GAS	A1
• MANUFACTURER'S SPECIFICATIONS ON CUPOLA HOT BLAST HEATER	A2-A3
• DATA ON SPACE HEATERS	A4
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• HISTORICAL DATA ON NATURAL GAS CONSUMPTION	A7

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO 41 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY [illegible] DATE MAR. 85	CHECKED BY DATE

LIST OF EQUIPMENT USING NATURAL GAS

1. ANNEALING FURNACE. RATED AT ~ 25 MMBTU/HR.
BASED ON MEASUREMENTS MAR 8/85, TYPICAL HOURLY CONSUMPTION ≅ 20.5MMBTU/h (GROSS HV)
ANNUAL CONSUMPTION ≅ $20.5 \times \frac{12\,h}{day} \times \frac{5\,day}{wk} \times$ [illegible]

$$\equiv \underline{64.0 \times 10^9\ BTU/yr}$$

2. CUPOLA HOT BLAST HEATER. RATED AT 9.8 MMBTU/HR
(FROM ORIGINAL PROPOSAL BY FABRICATING [illegible] 1980)
SEE ATTACHED SHEET

TYPICAL CONSUMPTION BASED ON DATA MEASURED FOR PROJECT 8829

$$= \frac{6000\ \frac{SCF}{MIN} \times 0.019\ \frac{BTU}{SCF\cdot{}^\circ F}\ (665-60) \times 60}{\text{assumed } 0.40 \text{ efficiency [illegible]}}$$

$= 10.3$ MMBTU/HR. → USE $\underline{10\ MMBTU/hr.}$
AT 40 H/WK, 52 WK/YR, ANNUAL USE = $\underline{20.8 \times 10^9\ BTU}$

③ VARIOUS SPACE HEATERS (19 UNITS)
TOTAL CAPACITY = 7,025,000 BTU/HR. (SEE ATTACHED SHEET)

SEASONAL CONSUMPTION = $\underline{(1.23)\,10^{10}\ BTU}$

④ EQUIPMENT FOR PREHEATING & DEHYDRATING
BASED ON J. BASICH COMMENTS, [illegible]
ABOUT ~ 0.5 MMBTU/MT (0.45 MMBTU/ST)
AT 12 STPH → 5.4 MMBTU/H
ANNUAL USE = $(5.4)10^6 \times 8 \times 5 \times 52 = \underline{(1.12)\,10^{10}\ BTU}$
DIVIDE EVENLY BETWEEN PREHEATING & DEHYDRATING.

DESCRIPTION, ENGINEERING DETAIL, PERFORMANCE
FABRICATING ENGINEERING COMPANY "THERMO"
SEPARATELY FIRED HOT BLAST HEATER
6000 CFM - 1025°F
STANTON PIPES, CANADA LTD.

Pg. A3

HEAT EXCHANGER (con't)

The velocities required are definite and well known and can be readily calculated by the designer; therefore, he can design for any tube metal temperature he desires. But as in all things in life you get nothing for nothing. It requires power to increase air velocities through the tubes and therefore he must make a compromise between power used to force the air through the heater and tube metal temperature.

It follows then that the unit having the lowest tube metal temperature for a specific alloy will have the longest life. In our design and control system we limit this vital criteria to most conservative values. For long life we limit our tube metal to the above listed values. No other heater manufacturer, to our knowledge, provides such safe operating tube metal temperatures.

These values of tube metal temperatures noted above gives the purchaser a good basis for judgment of various heaters for comparative purposes.

Inherently, only an all convection type heater wherein only hot gases enter the tube bank can produce such low tube metal temperatures.

Any radiant type heater obviously wherein the flame "sees" the heating surface and is adjacent to or is in the flame will operate with tube metal temperatures much higher and will therefore have a shorter life, when it is recalled that oxidation rates increase with alarming rapidity for relativel little temperature increase in the high temperature zones.

Tabulated below are the pertinent engineering characteristics of the unit.

TABULATION PERTINENT DESIGN DATA
FABRICATING ENGINEERING COMPANY [illegible]
SEPARATELY FIRED HOT BLAST HEATER
STANTON PIPES, CANADA LTD.

Heater outlet °F	1000°F
Cupola Air Flow: SCFM	6000 SCFM
Temperature Inlet Air °F	40°F
Permitted Maximum Outlet Temperature °F (Continuous)	1020°F
Temperature Hot Gases to Heat Exchanger	1700°F
Temperature Hot Gases Leaving Heat Exchanger	[illegible]40°F
Gas Consumption at Full Load CFH of 1000 BTU Gas	9800 |
Total Heating Surface Sq. Ft.	1930
Maximum Tube Metal Temperature:	
Front Bank	1290°F
Second Bank	1040°F
Third Bank	710°F
Pressure Drop Air Side " W.C.	22.0" W.C.
Combustion Air Fan Capacity*	5340 CFM @ 13.8" W.C. - 25 HP
Tube Bank Materials:	
Front Bank	304L Stainless Steel
Second Bank	4-6 Chrome And Steel
Third Bank	Steel

FIXED HEATING APPLIANCES GAS A4

	HEATER LOCATION	B.T.U./HR	M^3/HR	DAILY HOURS	WEEKLY M^3 USED	COST PER. W
3	CURING BAYS	225,000	6.3	24	1058.4	$179.9
1	MAKE-UP – S/D STACK	2,000,000	56.3	12	4729.2	803.9
1	NORTH END	2,000,000	56.3	12	4729.2	803.9
1	#3 LOCKER ROOM	200,000	5.6	24	940.8	159.9
1	#1 WASHROOM	200,000	5.6	24	940.8	159.9
1	STOCK ROOM	225,000	6.3	24	1058.4	179.9
1	MAIN PLANT OFFICE	200,000	5.6	24	940.8	159.
2	O.HEAD DOOR EAST L/D	600,000	16.9	12	2839.2	482.
2	O.HEAD DOOR SOUTH S/D.	600,000	16.9	12	2839.2	482.
1	SLAG ROOM	225,000	6.3	12	529.2	89.
1	MAINT. NORTH/WEST(R)	175,000	4.9	18	617.4	104.9
1	#2 MACH. INFRA RED	100,000	2.8	10	196.0	33.3
1	S/D STENCIL (R)	75,000	2.1	10	147.0	24.9
~~1~~	~~MAINT. OFFICE~~	CARRIER	HEAT	PUMP	ELECTRIC	
1	MAIN OFFICE LOWER	200,000	5.6	24		
1	MAIN OFFICE UPPER					
	TOTAL	7,025,000				

– TOTAL COST OF HEATING GAS PER WK. $3,66

– TOTAL HEATING GAS COST FOR ENTIRE HEATING SEASON OF 16 WKS. MID. NOV. TO MID. MARCH $58,662.

(1.23×10^{10} BTU per heating season)

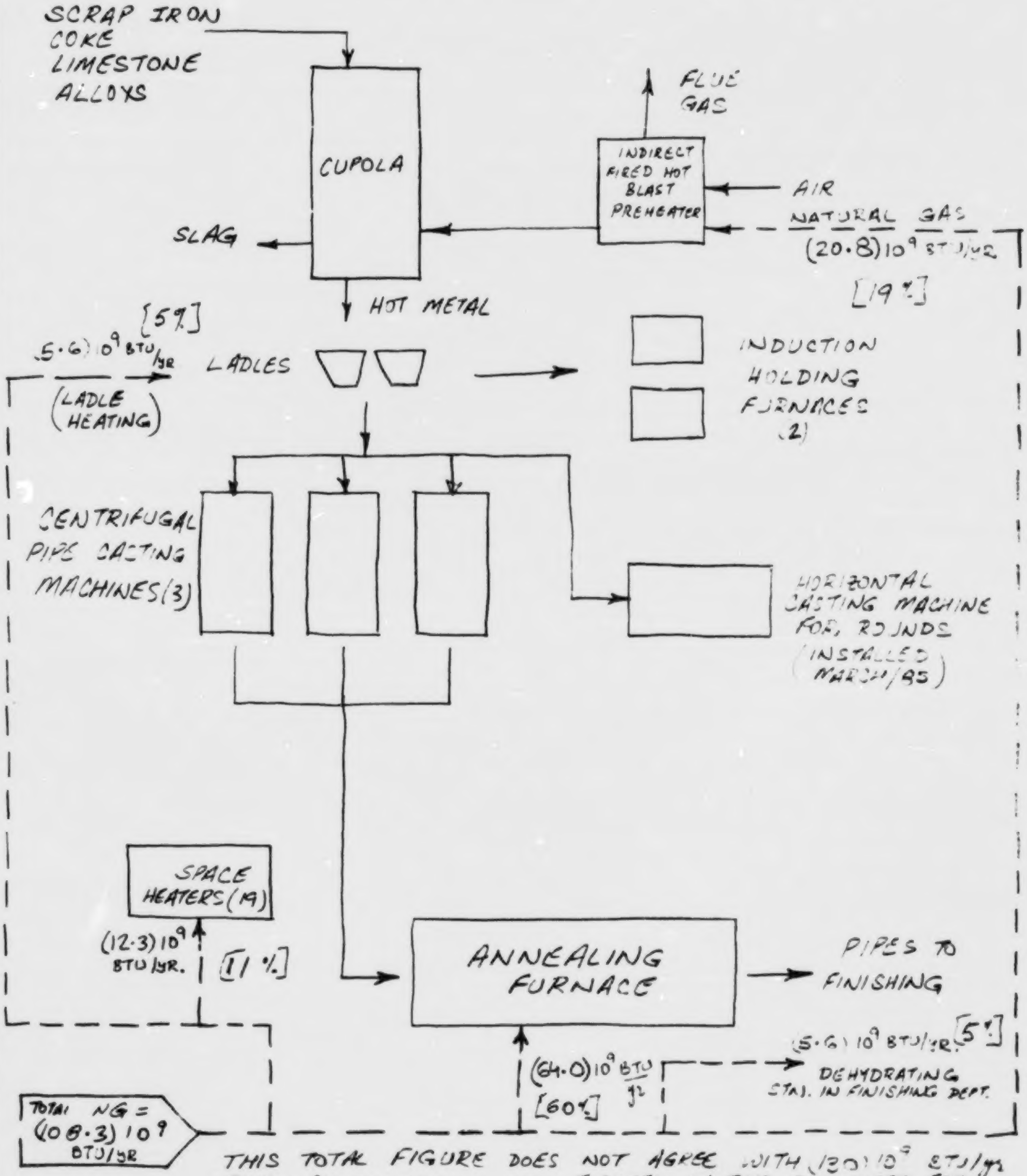
ASSUMPTIONS

- LENGTH OF HEATING SEASON AND SEVERITY.
- NUMBER OF HOURS OF HEATER OPERATION AT MAX. B.T.U
- THAT THE ABOVE TWO POINTS WILL AVERAGE THEMSELVE OUT TO APPROXIMATELY EQUAL THE ESTIMATE.
- THAT THE ABOVE CALCULATED ESTIMATE WILL BE THE MAXIMUM GAS USED.
- ALTHOUGH SOME OPERATING HOURS ARE BASED ON A SINGLE SHIFT THEY ARE ALSO FOR A 7-DAY WEEK WHICH CAN ABSORB ANY OVERTIME AND NOT EXCEED MAX

HATCH ASSOCIATES Consulting Engineers	**CALCULATION SHEET**	SHEET NO. A5 OF

DESCRIPTION	PROJ. NO.	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON	9036	SK	
		DATE	DATE

STANTON PIPES OPERATION – SIMPLIFIED FLOWSHEET & NATURAL GAS USAGE


SCRAP IRON
COKE
LIMESTONE
ALLOYS
CUPOLA
FLUE GAS
INDIRECT FIRED HOT BLAST PREHEATER
AIR
NATURAL GAS
(20.8)10⁹ BTU/YR
[19%]
SLAG
HOT METAL
[5%]
(5.6)10⁹ BTU/YR
(LADLE HEATING)
LADLES
INDUCTION HOLDING FURNACES (2)
CENTRIFUGAL PIPE CASTING MACHINES (3)
HORIZONTAL CASTING MACHINE FOR ROUNDS (INSTALLED MARCH/85)
SPACE HEATERS (19)
(12.3)10⁹ BTU/YR.
[11%]
ANNEALING FURNACE
PIPES TO FINISHING
(5.6)10⁹ BTU/YR.
[5%]
DEHYDRATING STN. IN FINISHING DEPT.
(64.0)10⁹ BTU/YR
[60%]
TOTAL NG = (108.3)10⁹ BTU/YR

THIS TOTAL FIGURE DOES NOT AGREE WITH (130)10⁹ BTU/yr GIVEN BY STANTON. ∴ USE FIGURES ON THIS FLOWSHEET FOR BREAKDOWN OF (130)10⁹ BTU TOTAL.

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Consulting Engineers

CALCULATION SHEET

SHEET NO. A6 OF

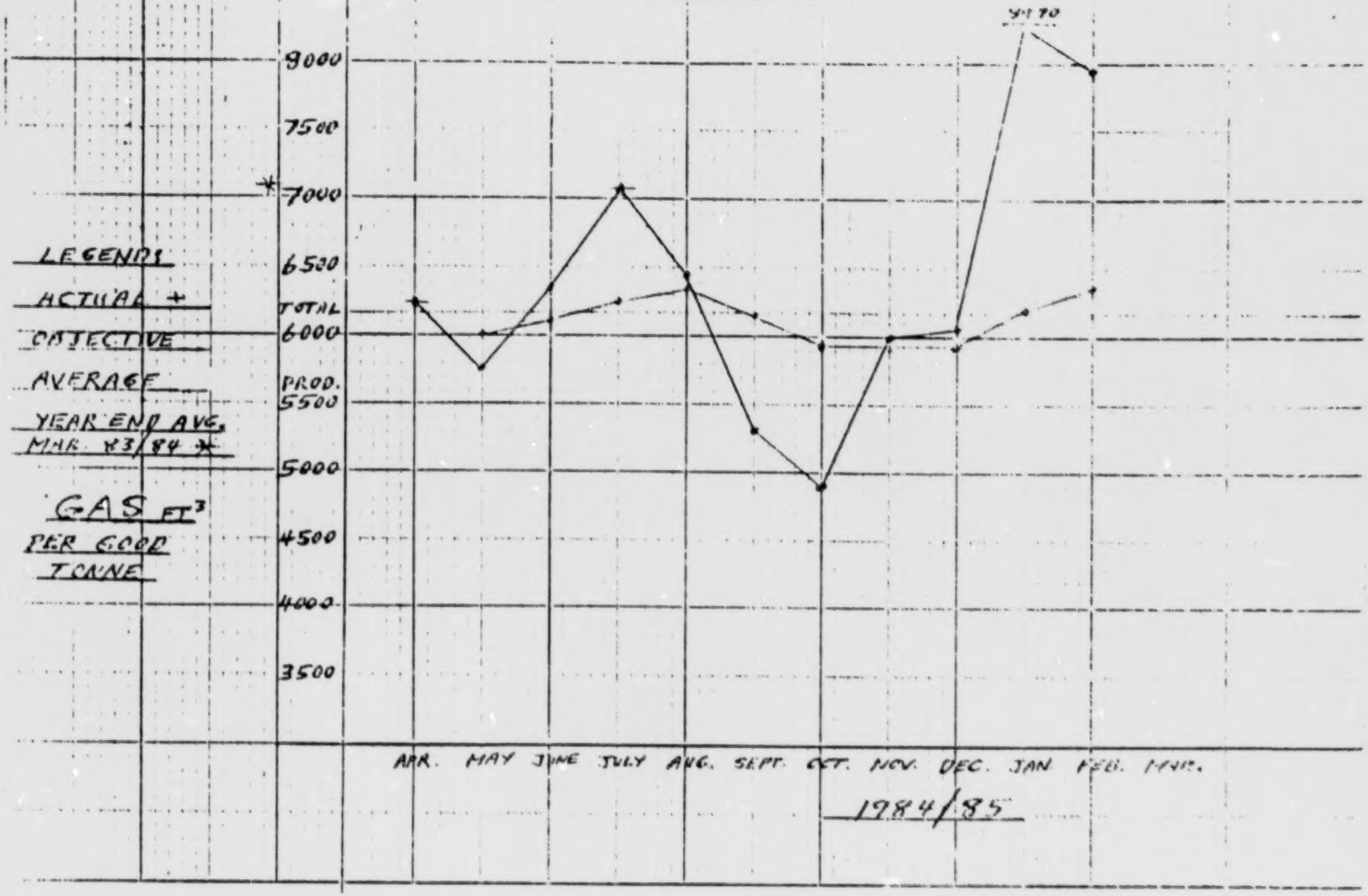
DESCRIPTION	PROJ NO	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON PIPES	9036	CK DATE MAR./85	DATE

ANNEALING FCE = 64.0 $\times 10^9$ BTU/YR [59%]
CUPOLA HOT BLAST = 20.8 [20%]
SPACE HEATERS = 12.3 [11%]
DEHYDRATING STN. = 5.6 [5%]
LADLE HEATING = 5.6 5%

TOTAL = (108.3) 10^9 BTU/YR.

THIS TOTAL FIGURE DOES NOT AGREE WITH (130) 10^9 BTU/YR GIVEN BY STANTON. THEREFORE USE ABOVE % FOR BREAKDOWN OF (130) 10^9 BTU/YR

GAS


9170
9000
7500
*7000
6500
TOTAL
6000
PROD.
5500
5000
4500
4000
3500
LEGENDS
ACTUAL +
OBJECTIVE
AVERAGE
YEAR END AVG.
MAR. 83/84 *
GAS FT³
PER GOOD
TONNE
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN
FEB.
MAR.
1984/85

Pg. A7

APPENDIX B

FIELD DATA AND ANALYSIS

CONTENTS:

	PAGES
• GAS METER READINGS FOR ANNEALING FURNACE CONSUMPTION	B1-B3
• PIPE TEMPERATURES, THROUGHPUT RATES, AND NET ENERGY TO PIPES	B4-B8
• FLUE GAS & AIR VOLUMES, TEMPERATURE, ENERGY	B9-B14
• FURNACE SHELL LOSSES	B15-B16
• FURNACE COOLING WATER & CONVEYOR LOSSES	B17
• TEMPERATURE READINGS OF INNER FURNACE & RADIATION LOSSES THROUGH OPENINGS	B18-B22
• OVERALL FURNACE ENERGY BALANCE	B23
• SCHEMATIC OF BURNERS & CONTROLS	B24-B25
• SUMMARY OF MEASUREMENTS OF BURNER SETTINGS	B26
• MANUFACTURER'S DATA ON BURNERS	B27

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CALCULATION SHEET

SHEET NO. 51 OF

DESCRIPTION: EMR ENERSOLVE - STANTON PIPES
PROJECT NO. 9036
MADE BY SK
DATE MAR. 11/85
CHECKED BY
DATE

SUMMARY OF GAS METER READINGS - MARCH 8/85

ALL GAS USERS EXCEPT ANNEALING FURNACE WERE TURNED OFF BETWEEN 10:00 A.M. AND NOON.

TIME	METER READING	T	P
9:15 (BEFORE TESTING)	724,497* × 100	4°C	1650
10:00 A.M.	724,508* × 100	5	1650
10:30	724,513.6 × 100	5	1650
11:00	724,519* × 100	5	1650
11:30	724,524.6 × 100	5	1650
NOON	724529* × 100	4	1650
2:56	724,571.9 × 100	6	1600

*** NOTE :** READING WAS NOT TAKEN TO DECIMAL PLACE, IE. THE RECORDED VALUE IS A TRUNCATION.

METER CALIBRATION : ACTUAL GAS CONSUMPTION (CF)

= (Δ METER READING) × PRESSURE FACTOR × TEMP. FACTOR × SUPER COMPRESSIBILITY

FOR P = 1650, P-FACTOR = 17.2641 ; T = 5°C, T-FACTOR = 1.0360 ; SUPERCOMPRESSIBILITY FACTOR = 1.0403

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. B2 OF

DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036 •	MADE BY SK DATE MAR/85	CHECKED BY DATE

GAS CONSUMPTIONS :

START TIME	END TIME	Δ TIME	CONSUMPTION
9:15	10:00	0.75 h. (BEFORE TEST PERIOD & OTHER EQPMT. STILL ON)	(508-497)100(17.2641) × (1.036)(1.0403) = 20,470 cf or 27,300 CF/H
10:00	10:30	0.5h.	(13.6-8)100(18.6064) = 10,420 cf or 20,800 CF/h
10:30	11:00	0.5h	(19-13.6)100(18.6064) = 10,050 cf or 20,100 CF/h
11:00	11:30	0.5h	(24.6-19)100(18.6064) = 10,420 cf or 20,800 CF/h
11:30	12:00	0.5h	(29-24.6)100(18.6064) = 8,190 cf = 16,400 CF/h (LOWER POSSIBLY DUE TO TRUNCATION ON METER READING)
12:00	2:56	2.93h.	ASSUMING SAME CALIBRATIO (71.9-29)(1860.64) = 79,820 cf or 27,200 CF/h

DURING MAIN DURATION OF TESTS, CONSUMPTION ≃ 20,500 cf/h

AT ≃ 900 BTU NET/CF ⇒ 18.5 MMBTU/h FUEL

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CALCULATION SHEET

SHEET NO. 33 OF			
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE MAR./85	CHECKED BY DATE

FUEL CONSUMPTION FOR START-UP OF FURNACE

TOTAL PLANT CONSUMPTION DURING 1 HR. START-UP PERIOD
= 32,973 cf ON MARCH 19/85

HOT BLAST WILL BE ON FOR ≃ 1/2 HR. IN THIS PERIOD,
ITS CONSUMPTION $\simeq (10)10^3 \frac{cf}{h} \times 0.5h$

$= 5,000$ cf

ALLOW ANOTHER 5,000 cf FOR SPACE HEATERS AT THIS TIME

∴ ESTIMATED FCE. CONSUMPTION $\simeq 33,000 - 10,000$
$\simeq 23,000$ cf
(or 23 MMBTU/h)

THIS IS CLOSE TO RATED
CAPACITY FOR OPERATING
BURNERS

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CALCULATION SHEET

SHEET NO. 54 OF

DESCRIPTION	PROJ NO	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON PIPES	9036	SK MAR 12/85 DATE	DATE

PIPE TEMPERATURES - MAR. 8/85

MEASUREMENTS WERE TAKEN OF PIPE TEMPERATURES ENTERING & EXITING THE FURNACE.

		T_{IN} (°F)		T_{OUT} (°F)			
PIPE #	PIPE DIA.	RANGE	AVG.	RANGE	AVG.	ΔT (°F)	NOTES
78	7"	–	1100	1300-1400	1350	250	IN - 10:00 AM OUT - 10:57
92	8	–	1110	1200-1250	1225	115	
79	7"	–	1050	1300-1300	1300	250	
93	8"	–	1100	1150-1250	1200	100	
94	8"	–	1050	1150-1200	1175	125	
80	7"	800-1080	940	1250-1320	1285	345	
95	8"	1080-1130	1100	1150-1200	1175	75	
81	7"	–	1100	1250-1320	1285	185	
96	8"	1100-1150	1125	1200-1250	1225	100	
82	7"	1050-1200	1125	1200-1300	1250	125	
97	8"	1050-1200	1125	1180-1250	1215	90	
83	7"	1000-1200	1100	1150-1280	1215	115	
98	8"	1100-1250	1175	1250-1250	1250	75	
84	7"	1100-1250	1175	1250-1300	1275	175	
99	8"	–	–	1200-1250	1225	–	
85	7"	–	1050	1250-1300	1275	225	
100	8"	–	1100	1250-1300	1275	175	
101	8"	1100-1300	1200	1250-1300	1275	75	
86	7"	800-900	850	1300-1350	1325	475	
87	7"	1050-1150	1100	1300-1350	1325	225	
88	7"	950-1100	1025	1250-1300	1275	250	
102	8"	950-1200	1075	1200-1350	1275	200	
103	8"	1000-1110	1055	1200-1300	1250	195	IN - 10:30 AM
89	7"	1050-1100	1075	1250-1300	1275	200	OUT - 11:30 AM
104	8"	950-1100	1025	1200-1250	1225	200	
90	7"	1110-1200	1150	1300-1390	1345	195	
105	8"	1000-1250	1125	1250-1300	1275	150	
106	8"	1000-1260	1130	1250-1300	1275	145	
91	7"	1000-1100	1050	1300-1350	1325	275	OUT ~ 11:45 AM

AVG: 7" - 1063 °F (σ = 84 °F)
8" - 1106 °F (σ = 47 °F

HATCH
ASSOCIATES

CALCULATION SHEET

SHEET NO. B5 OF

DESCRIPTION EMR ENERSOLVE – STANTON PIPES	PROJECT NO. 9036	MADE BY SK DATE	CHECKED BY DATE

FROM PROJECT 8829, TYPICAL ALLOY CONSTITUENTS OF CAST PIPES:

C - 3.3%
Si - 1.9%
Mn - 0.4%

FROM PERRY'S (Pg. 3-120 → 123), HEAT CAPACITY AT 1200°F:

Fe - 10.00 cal/deg-mole
C - 4.94 cal/deg-mole
Si - 6.19 cal/deg-mole
Mn - 10.63 cal/deg-mole

SINCE Fe IS MAJOR CONSTITUENT, AND WITH THE ABOVE VARIATIONS IN C_p, USE C_p BASED ON Fe ALONE

AT 1000°F (810°K), $\left.C_p\right)_{Fe}$ = 9.30 cal/deg-mole

1400°F (1033°K), $\left.C_p\right)_{Fe}$ = 10.72 cal/deg-mole

USE $C_p \simeq$ 10.0 cal/deg K-mole

$$\simeq \frac{10.0}{55.847} = 0.179 \frac{cal}{°K\text{-}gm} = (7.103)10^{-4} \frac{BTU}{°K\text{-}gm}$$

$$= 0.179 \frac{BTU}{lb\text{-}°F} \qquad \text{FOR } 1000 \le T \le 1400°F$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO B6 OF

DESCRIPTION	PROJ NO	MADE BY	CHECKED
EMR. ENERSOLVE - STANTON PIPES	9036	SK DATE	DATE

7" PIPES : TOTAL OF 14 PIPES MEASURED
AVG. $\Delta T \simeq 235\,^\circ F \quad (\sigma = 91\,^\circ F)$
TOTAL WEIGHT = 575 LBS

8" PIPES : TOTAL OF 14 PIPES MEASURED
AVG. $\Delta T \simeq 130\,^\circ F \quad (\sigma = 42\,^\circ F)$
TOTAL WEIGHT = 570 LBS.

∴ HEAT GAIN BY THESE TRACKED PIPES

$$= 14 \times 575 \text{ LBS} \times .179 \frac{\text{BTU}}{\text{LB-}^\circ\text{F}} \, 235\,^\circ\text{F})$$

$$+ 14 \times 570 \times .179\,(130\,^\circ\text{F}) = 524{,}300 \text{ BTU}$$

$$\text{or } \frac{524{,}300 \times 2000}{14(570+575)} = \underline{65{,}400 \frac{\text{BTU}}{\text{TON}}}$$

PRODUCTION RATE:
29 PIPES IN ≃ 48 MINS. (0.8 hr)
AVG. WT. ≃ 572.5 LBS.

$$\therefore \text{ AVERAGE PRODUCTION RATE} = \frac{29 \times 572.5}{0.8} = 20{,}750 \frac{\text{LB}}{\text{HR.}}$$

$$= \underline{10.4 \text{ TPH}}$$

∴ HEAT TO PIPES

$$= 65{,}400 \frac{\text{BTU}}{\text{TON}} \times 10.4 \frac{\text{TON}}{\text{H}} = \underline{0.68 \text{ MMBTU/HR.}}$$

ENERGY REQUIRED TO HEAT 1 TON FROM 1100 °F TO 1800 °F

$$= 2000 \times \left(.179 \frac{\text{BTU}}{\text{LB-}^\circ\text{F}}\right) \times (1800 - 1100) = \underline{0.25 \frac{\text{MMBTU}}{\text{T}}}$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. E7 OF
DESCRIPTION EMR. ENERSOLVE - STANTON PIPES	PROJ NO. 9036	MADE BY MAR 12/85 DATE
		CHECKED BY DATE

SUMMARY OF PIPE SIZES & WEIGHTS

PIPE DIA.	SOCKET WEIGHT	TOTAL WEIGHT 18' LENGTH	TOTAL WEIGHT 20' LENGTH
4"	9 LBS.	235 LBS.	260 LBS.
6"	11	365	405
7"	NO SOCKET	575	–
8"	17	515	570
10"	24	675	750
12"	29	850	940
14"	45	1050	
16"	54	1230	
18"	59	1415	
20"	74	1615	
24"	95	2025	

NOTES:

1. LENGTHS LISTED EXCLUDE SOCKET LENGTH OF 3½"-4½", THEY ARE LAYING LENGTHS. (USE 4" AVG)
2. ALL WEIGHTS EXCEPT FOR 7" PIPE ARE FOR CLASS 52 THICKNESS (MOST COMMON TYPE). THE 7" DIA. PIPE IS CLASS 44.

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Consulting Engineers

CALCULATION SHEET

SHEET NO. 53 OF

DESCRIPTION EMR ENERSOLVE - STANTON PIPES

PROJ NO 7036

MADE BY SK

DATE MAR./85

CHECKED BY

DATE

ANALYSIS OF WEIGHT/LENGTH OF PIPE :
FOR 18' LENGTH PIPE

PIPE DIA.	(LBS. / FT. LENGTH) SOCKET SECTION	NON-SOCKET SECTION
4"	27.0	12.6
6"	36.7	19.7
8"	51.5	27.7
10"	72.7	36.2
12"	87.9	45.6
14"	136.4	55.8
16"	163.6	65.3
18"	178.8	75.3
20"	224.2	85.6
24"	287.9	107.2

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

SHEET NO. 87 OF

DESCRIPTION	PROJ NO.	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON PIPES	9036	DATE MAR/85	DATE

ENERGY IN FLUE GASES

AIR WAS OBSERVED TO BE ENTERING THE FURNACE THROUGH THE ENTRANCE END & DOORS.

THE VELOCITY OF GASES EXITING FURNACE AT DISCHARGE END ≃ 3-5 FPS, ALLOW 5 FPS AVG. AS MEASUREMENT WAS TAKEN NEAR EDGE

GAS TEMPERATURE ≃ 1300 °F

AREA OF FLOW ≃ 24' x 3' = 72 ft²

∴ FLOW = 72 × 5 = 360 cfs ≡ 21,600 CFM

$$\text{SCFM FLOW} = 21,600 \times \frac{520}{1760} = \underline{6380 \text{ SCFM}}$$

USE C_p SLIGHTLY HIGHER THAN AIR.

$$\text{HEAT PICK-UP} \simeq 6380 \frac{\text{SCF}}{\text{MIN}} \times \frac{60 \text{ MIN}}{\text{H}} \cdot .021 \frac{\text{BTU}}{\text{SCF °F}} (1300-60)$$

$$= \underline{10.0 \text{ MMBTU/H}}$$

THE 20,500 CF/H GAS RESULTS IN

$$\simeq \frac{20,500 \times 11}{60} = 3760 \text{ SCFM FLUE}$$

GAS AT 10:1 AIR-FUEL RATIO

AIR FLOW AT 10:1 RATIO = 20,500 × 10/60 = 3420 SCFM
AIR FLOW AT STOICHIOMETRIC = 20,500 × 9.5/60 = 3,250 SCFM
ACTUAL AIR FLOW ≃ 6380 − 20,500/60 = 6040 SCFM

∴ RATIO OF ACTUAL AIR FLOW : STOICHIOMETRIC

$$\simeq \frac{6040}{3250} = 1.86$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. 810 OF
DESCRIPTION EMR ENERSOLVE	PROJ. NO. 9036	MADE BY CK. APR./85 DATE	CHECKED BY DATE

CHECK OPERATION OF COMBUSTION BLOWERS FOR AIR TO BURNERS:

FIELD MEASUREMENTS:

a) BLOWER FOR PRE-HEAT ZONE -
460 VOLTS, 22.5 A, 3-PHASE MOTOR

$$BHP = \frac{\sqrt{3}\, V \cdot I}{746} \times \text{POWER FACTOR} \times \text{ELEC. EFFIC.}$$

$$\simeq (\sqrt{3})\, 460\, (22.5)\, (.9) \times (0.9) / 746$$

$$= 19.5 \text{ HP}$$

FROM MFR. DATA ON 9916-200 BLOWER, (Pgs. 811-814)
AIR FLOW AT THIS POWER (RATED) ~ 3000 SCFM

b) BLOWER FOR OTHER ZONES -
460 V, 11.5 A, 3-PHASE MOTOR

$$BHP \simeq \sqrt{3}\, 460\, (11.5)(.9)(.9)/746 \simeq 10 \text{ HP}$$

THIS IS ALSO AT THE RATED CAPACITY FOR THIS BLOWER, AT WHICH FLOW $\simeq$ 2200 SCFM
(SEE Pg. 827)

$\therefore$ AIR FLOW TO BURNERS = 2200 + 3000 = 5200 SCFM*

$\therefore$ INFILTRATION AIR INTO FURNACE
$\cong$ 6040 − 5200 = 840 SCFM*

$$\text{AIR-FUEL RATIO AT BURNERS} = \frac{5200}{340} \cong 15:1$$

* SINCE THE VOLUME ESTIMATE FOR AIR THROUGH BURNERS IS ROUGH ONLY, USE THE ESTIMATED INFILTRATION AIR & AIR FLOW TO BURNERS AS A GUIDE : NCY.

551

INDUSTRIAL HEAT PROCESSING EQUIPMENT

CANEFCO LIMITED

50 MILNE AVE., SCARBOROUGH, ONT. M1L 1K[illegible]
Telephone 691-2117
Cable Address: CANFURNO

RECEIVED MAR 3 1 1980

Rec'd March 3/80

March 27th, 1980

Stanton Pipes Ltd.,
P. O. Box 849,
Kenilworth Ave. North,
Hamilton, Ontario.
L8N 3N9

Attention: Gido Kelly

Subject: Furnace Serial No. 1343
Canefco ER 1343-5

We submit our quotation on your requirements for new Fan for your 20 HP Air Blower.

As the model on your furnace is obsolete and we no longer make this we offer the following:

1 Bloom # 9916-200, 2990 CFM at 16 oz with 20HP Motor but less starter (See enclosed bulletin)

Price... $4,225.00

Delivery 26 weeks.

Prices are F.O.B. our plant, Scarboro, Ont. Terms net. Taxes extra.

Quotation is firm until April 23rd, 1980

I am sorry that you were not available on [illegible], when I was in Hamilton, but hope to meet you on my next visit. I did speak to Roy Graves and asked regarding our quotation ER 1343-4 covering Stainless Curtains and Rail Chair Casting.

Awaiting your comments.

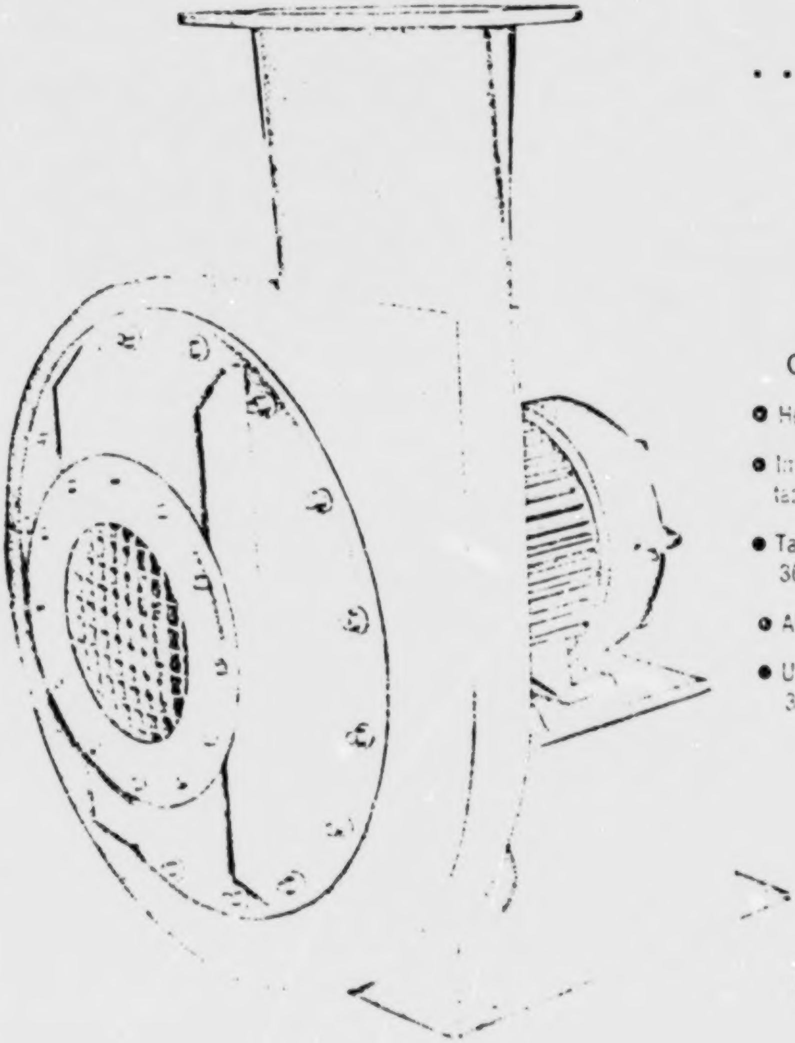
Yours truly,

R. A. [illegible],
[illegible] Replacement Parts
[illegible]

[illegible] impeller and [illegible] for a new [illegible] a bit [illegible] impeller [illegible] requirement [illegible]

B12

BLOOM 9900 Series Pressure Blowers . . .



. . .for Heavy Duty Combustion Air Applications

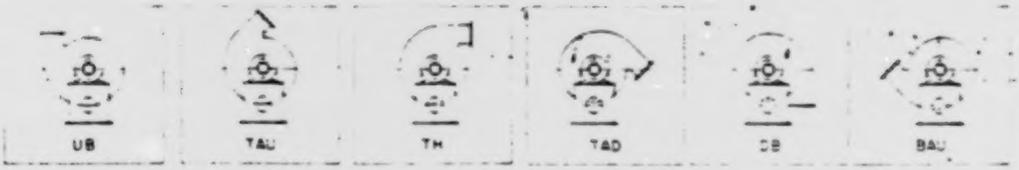
OUTSTANDING FEATURES

- Heavy steel plate construction throughout.
- Impellers — mild steel, radial bladed with tapered shroud for rigidity.
- Taper lock hub construction for all 3600 rpm blowers.
- All blowers statically and dynamically balanced
- Universal housing furnished with all 3600 rpm blowers as standard feature

SINGLE STAGE BLOWERS
1800 and 3600 RPM
ARRANGEMENT NO. 4

[illegible]
[illegible]

STANDARD FAN DISCHARGE POSITIONS AVAILABLE

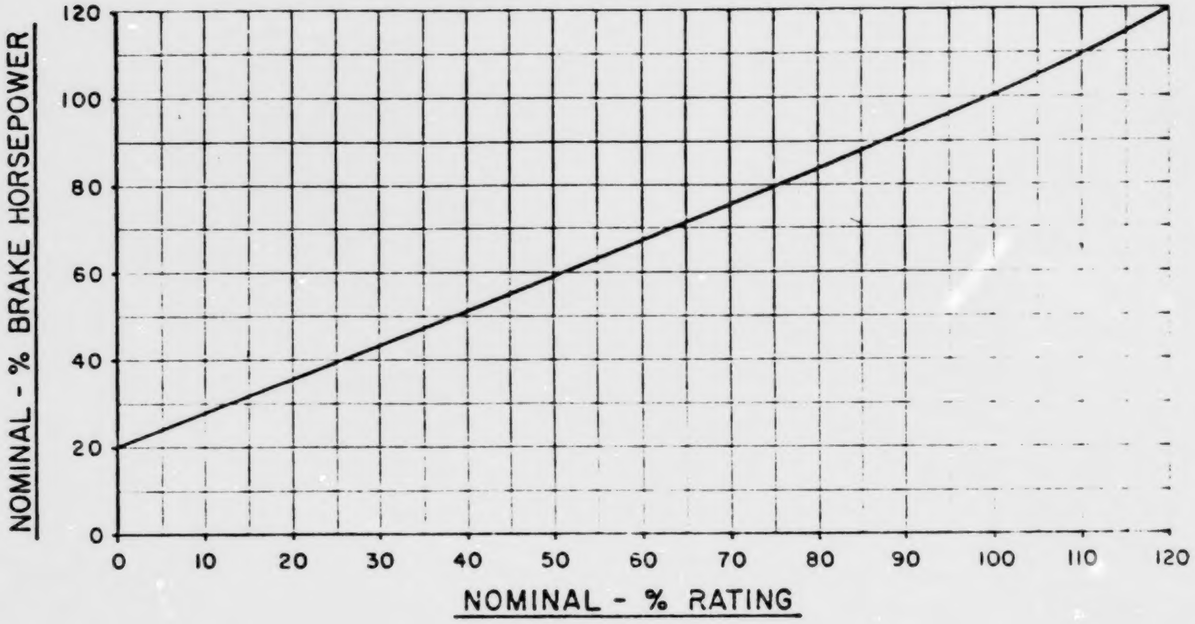


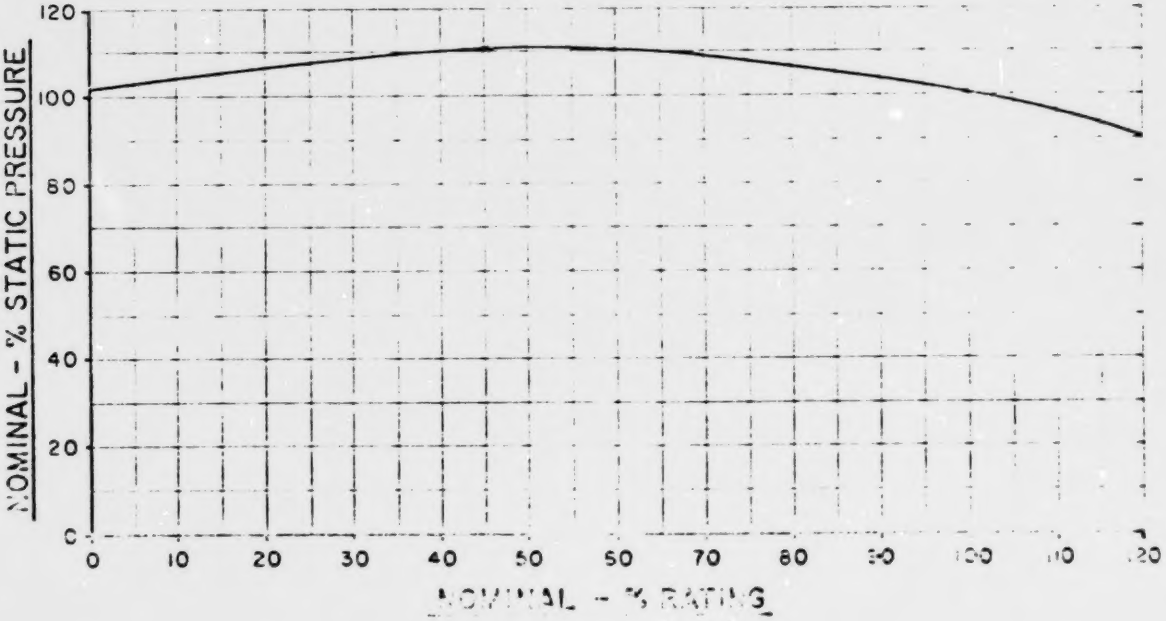
	CATALOG NUMBER	CFM	DIMENSIONS (IN INCHES)									APPROX.
			A OUTLET	B INLET	C	D	E	F	G	H	J	WT. LBS.
16 OZ. PRESSURE	9916-03A	225	5	6	33¾	22½	24	12½	7¾	12¾	7⅞	550
	9916-030	395	8	5¾	33¾	31	34¾	23	11½	20½	7	406
	9916-050	630	8	6	33¾	31	34¾	23	11½	20½	7	429
	9916-074	1,120	8	8	38 11/32	24 15/16	33 9/16	22⅞	11 29/32	19	6⅞	507
	9916-100	1,500	8	8	38 11/32	27 15/16	33 9/16	22⅞	11 29/32	19	6 13/16	539
	9916-150	2,240	10	10	38⅜	29¾	34 13/16	22⅞	11 29/32	20½	7⅜	627
	9916-200	2,990	10	12	38 11/32	30⅞	34 13/16	22⅞	11 29/32	20½	5⅝	582
	9916-250	3,730	12	12	38 11/32	32	36 9/16	22⅞	11 29/32	22	[illegible]	740
	9916-300	4,330	14	12	38 11/32	32 9/16	37 9/16	22⅞	11 29/32	23	6½	[illegible]
	9916-400	5,630	14	14	38 11/32	35 11/16	37 13/16	22⅞	11 29/32	23	5¾	950
18 OZ. PRESSURE	9918-074	940	8	10	41 25/32	24 7/16	35 27/32	25 1/16	12 29/32	20½	6¾	541
	9918-100	1,250	8	10	41 13/16	27¾	35 9/32	25 1/16	12 29/32	20	6 23/32	579
	9918-150	1,770	10	10	40 19/32	27⅞	35⅝	24¾	12 19/32	21	6 29/32	667
	9918-200	2,600	12	10	41 25/32	29⅞	38 15/32	25 1/16	12 29/32	23	6⅞	722
	9918-250	3,330	12	12	41 25/32	31¾	38 15/32	25 1/16	12 29/32	25	7 9/32	780
	9918-300	3,850	12	14	45¾	31 13/16	41 9/32	27 1/16	13⅝	25	6 13/16	840
	9918-400	5,050	14	14	39⅜	35½	40½	26	13⅝	24	6 11/16	990
28 OZ. PRESSURE	9920-03A	180	4	5	23¾	24½	24	12½	7¾	12¾	11	550
	9920-05A	310	4	6	23¾	27½	24	12½	7¾	12¾	12⅝	575
	9920-050	400	6	5	42½	31	37½	25½	12¾	21¾	6¾	514
	9920-074	840	8	10	43	24 9/16	37½	25¾	12 9/16	21	6 7/16	586
	9920-100	1,150	8	10	42½	27¾	35¾	25¾	12 9/32	22½	6 7/16	624
	9920-150	1,760	8	10	45⅜	28 1/16	38½	27⅝	[illegible]	21½	6 9/16	[illegible]
	9920-200	2,400	10	10	42½	30⅜	37¾	25½	[illegible]	21½	[illegible]	[illegible]
	9920-250	2,920	12	12	42½	[illegible]	35¾	25¾	[illegible]	23	[illegible]	[illegible]
	9920-300	3,660	12	12	42½	32⅜	35¾	25¾	[illegible]	23	6⅝	885
	9920-400	4,500	14	14	42½	36½	39¾	25¾	12 9/32	24	7	1035
	9920-500	5,640	14	14	[illegible]	37¾	41¾	25⅝	14	25	[illegible]	[illegible]
24 OZ PRESSURE	9924-03A	150	4	5	23¾	24½	24	12½	7¾	12¾	11	[illegible]
	9924-05A	[illegible]	4	6	23¾	24½	24	12½	7¾	12¾	11	[illegible]
	9924-050	330	4	6	23¾	27½	24	12½	7¾	12¾	12⅝	[illegible]
	9924-074	625	6	8	34⅞	24	35⅞	18	11¾	19	6	[illegible]
	9924-100	1,000	8	10	46½	27⅞	36⅞	27¾	14 9/16	21½	6½	[illegible]
	9924-150	1,500	8	10	46½	29¾	38⅞	27¾	14 9/16	21½	[illegible]	[illegible]
	9924-200	2,000	10	10	46¾	[illegible]	40¾	27⅝	[illegible]	23	6¾	[illegible]
	9924-250	[illegible]	12	10	46½	[illegible]	41⅞	27¾	[illegible]	24½	[illegible]	[illegible]
	9924-300	3,000	12	12	46½	[illegible]	41⅞	27¾	[illegible]	24½	[illegible]	[illegible]
	9924-400	4,030	12	12	46¾	38 9/16	41¾	27¾	14 9/16	24½	[illegible]	1090
	9924-500	5,250	14	12	46 15/16	38 11/16	[illegible]	28	14⅝	26	7¾	1150
	9924-600	5,900	14	14	50⅝	35¾	45	29¾	15½	28½	7 9/16	[illegible]
32 OZ PRESSURE	9932-05A	125	4	6	[illegible]	23½	29¾	14	9¾	15¾	[illegible]	[illegible]
	[illegible]	[illegible]	6	6	[illegible]	26½	[illegible]	15	[illegible]	15¾	[illegible]	[illegible]
	[illegible]	425	6	8	34⅞	[illegible]	[illegible]	18	11¾	19	[illegible]	[illegible]
	[illegible]	[illegible]	6	8	34⅞	[illegible]	[illegible]	18	11¾	19	[illegible]	[illegible]
	[illegible]	[illegible]	8	[illegible]	40⅞	28	41⅞	[illegible]	14	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	8	[illegible]	[illegible]	28¾	40¾	32	[illegible]	24	[illegible]	[illegible]
	9932-250	[illegible]	10	[illegible]	53⅜	29¾	44⅞	32	[illegible]	25	7⅝	[illegible]
	[illegible]	[illegible]	10	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	26	6⅝	[illegible]
	[illegible]	[illegible]	12	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	12	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	14	14	[illegible]	[illegible]	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: Do Not Use Dimensions For Construction

Clear Blower Number [illegible] CFM
Shaded Blower Number [illegible] CFM

Bloom Blowers - Pressure And Horsepower


BRAKE HORSEPOWER


STATIC PRESSURE

BLOOM ENGINEERING CO., INC.

Horning and Curry Roads - Pittsburgh, PA 15236

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO. 815 OF
DESCRIPTION EMP. ENERSOLVE - STANTON PIPES		PROJ. NO. 9036	MADE BY SK DATE MAR/85	CHECKED BY DATE

FURNACE SHELL LOSSES

MEASURED TEMPERATURES:

a) OUTSIDE SHELL OF FLOOR.

COOL ZONE : 52°C
SOAK ZONE : 75°C, 77°C
PREHEAT ZONE : 60°C

STRAIGHT AVERAGE = 66°C = 150°F

SHELL AREA OF FLOOR ≃ 72' LONG × 26' WIDE
= 1872 ft²

b) OUTSIDE SHELL OF SIDEWALLS

	WEST SIDE	EAST
COOL ZONE :	150, 90, 112°C (117°C)	155, 90, 95°C (113°C)
SOAK ZONE :	65, 116°C (90°C)	180, 260°C (220°C)
PREHEAT ZONE :	36°C, 40 (38°C)	32, 65°C (49°C)

(NOS. IN BRACKETS ARE AVERAGES)

SHELL AREAS: (EA. SIDE)

COOL = 27' × ~7' AVG. HT. = 189 ft²
SOAK = 23' × ~7' = 161
PREHEAT = 22' × ~7' = 154

c) ROOF SHELL TEMPERATURES - NOT MEASURED
TAKE AS AVG. OF EAST & WEST SIDEWALL TEMPS. FOR THAT ZONE.

	T	SHELL AREA
COOL	115°C	27 × 26 = 702 ft²
SOAK	155°C	23 × 26 = 598
PREHEAT	44°C	22 × 26 = 572

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. 816 OF......
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE MAR/85	CHECKED BY DATE

OVERALL HEAT TRANSFER COEFFICIENT FROM SHELL:

$$(h_c + h_r) \sim 3 \frac{BTU}{h\text{-}ft^2\text{-}°F}$$

ROOM TEMP. ≃ 85 °F

$$\therefore \text{ SHELL HEAT LOSS} = 3 \left\{ \begin{array}{l} 1872\,(150 - 85) + \\ 189\,(243 - 85) + 189\,(235 - 85) + \\ 161\,(194 - 85) + 161\,(428 - 85) + \\ 154\,(100 - 85) + 154\,(120 - 85) + \\ 702\,(239 - 85) + 598\,(311 - 85) + \\ \quad 572\,(111 - 85) \end{array} \right\}$$

$$= \underline{1.56 \text{ MMBTU/H}}$$

HATCH ASSOCIATES	CALCULATION SHEET		SHEET NO. 817 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJECT NO. 9036	MADE BY SK DATE MAR. 11/85	CHECKED BY DATE

ANNEALING FURNACE COOLING WATER

THERE ARE 5 RETURN PIPES (~ 3/4" DIA. EA. - ESTIMATE) WHICH EMPTY INTO AN OPEN TROUGH.

THE TEMPERATURE & FLOWRATE OF EACH PIPE WAS MEASURED.

PIPE	TEMP.	TIME TO FILL 280 ML. CONTAINER	FLOWRATE (ml/s)	FLOWRATE ft³/s
A	110 °F	0.6 sec.	467	0.016
B	140	1.9	147	0.005
C	140	1.5	187	0.007
D	140	1.5	187	0.007
E	NO	FLOW	—	—

SHELL TEMP. OF PIPE FOR TOTAL FLOW TO FCE.
≃ 27°C ≅ 81 °F.

PIPE IS NOT INSULATED, ∴ TAKE WATER TEMP ≃ 81 °F

∴ HEAT PICK-UP BY COOLING WATER

$$\simeq \{(.016)(110-81) + (.005)(140-81) + (.007)(140-81) + (.007)(140-81)\} \frac{ft^3}{s} \times 1.0 \frac{BTU}{lb\text{-}°F} \times [illegible]$$

= 99 BTU/s = 0.36 MMBTU/h

SENSIBLE LOSSES OF CONVEYOR

ESTIMATE IT TO BE ABOUT SAME AS COOLING WATER
≃ 0.4 MMBTU/h

HATCH ASSOCIATES
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CALCULATION SHEET

DESCRIPTION EMP. ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY SK DATE MAR./85	SHEET NO 5/9 OF CHECKED DATE

TEMPERATURE MEASUREMENTS WITHIN FURNACE

LOCATION	TEMPERATURE MEASURED	ε ON PYROMETER
A) 5' FROM FCE. INLET	ancB" PIPE: 1100-1300 °F a 7" PIPE: 1000	0.9
B) THROUGH DOOR 1	EAST SIDEWALL = 1700 °F ROOF = 1800 °F amB" PIPE: 1680-1800 °F a 7" PIPE: 1630-1750 °F	0.9

NO MEASUREMENTS POSSIBLE AT DOOR 2 AS FLAMES COMING OUT.

LOCATION	TEMPERATURE MEASURED	ε ON PYROMETER
C) THROUGH DOOR 3	~1650 °F UNIFORMLY INSIDE EVERYWHERE	1.0
D) THROUGH DOOR 4	~1800 °F EVERYWHERE	0.9
E) THROUGH DOOR 5	PIPE : 1520-1550 °F EAST SIDEWALL ≃ 1200 °F ROOF : 1530 °F	0.9
F) THROUGH DOOR 6	PIPE : 1400-1480 °F EAST SIDEWALL ≃ 1200 °F ROOF : 1420 °F	0.9

RADIATION LOSS $= \sigma \varepsilon F A (T_i^4 - T_o^4)$

σ → STEFAN-BOLTZMANN CONSTANT
ε → EMISSIVITY
F → VIEW FACTOR
A → AREA
T_i → HOT SURFACE TEMPERATURE
T_o → AMBIENT TEMP.

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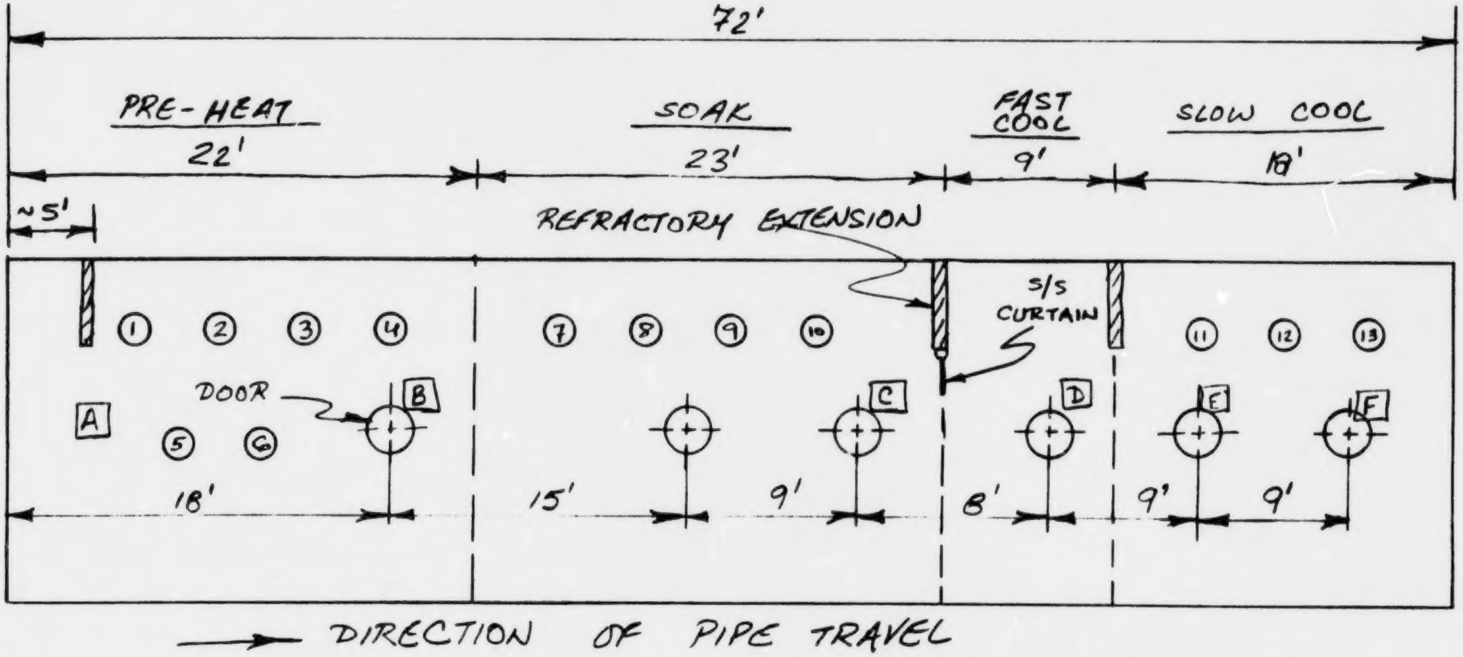
CALCULATION SHEET

SHEET NO B19 OF

DESCRIPTION	PROJ NO	MADE BY / DATE	CHECKED BY / DATE
EMR ENERSOLVE - STANTON PIPES	9036	SK MAR/85	


72'
PRE-HEAT
22'
SOAK
23'
FAST COOL
9'
SLOW COOL
18'
~5'
REFRACTORY EXTENSION
S/S CURTAIN
DOOR
A
B
C
D
E
F
1
2
3
4
5
6
7
8
9
10
11
12
13
18'
15'
9'
8'
9'
9'
DIRECTION OF PIPE TRAVEL

SCHEMATIC LAYOUT OF FURNACE

FURNACE WIDTH: ~24' INS., 26' OUT.
OPENINGS AT ENTRANCE & EXIT ENDS: ~ 3' x 24'
FLOOR - INSIDE ROOF DISTANCES: 6' (ENTRANCE), 5' (EXIT)
DISTANCE FROM FLOOR - END OF REFRACTORY EXTENSIONS: 3'

LEGEND: ☐ INDICATES LOCATION OF TEMPERATURE MEASUREMENTS LISTED ON PAGE B18

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. B20 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY SK DATE MAR/85	CHECKED B DATE

RADIATION LOSSES THROUGH ROUND SIDE DOORS:

$$= \sigma \varepsilon F A (T_i^4 - T_o^4)$$

TOTAL OF 6 OPEN

TAKE $F = 1.0$ (VIEW FACTOR)

20" Φ EA. (1.67' Φ)

$\varepsilon \simeq 0.9$

$T_{AVG} \simeq 1550$°F IN COOLING ZONE $\left(\frac{1800+1300}{2}\right.$

$$\therefore \text{HT. LOSS} = (.1714)\left(6 \times \frac{\pi(1.67)^2}{4}\right)(0.9)(20.1^4 - 5.45^4)$$

$$= \underline{(0.33)\ \text{MMBTU/HR}}$$

RADIATION LOSSES THROUGH DISCHARGE DOOR

$$= (.1714)(24 \times 3)(.9)(20.1^4 - 5.45^4)$$

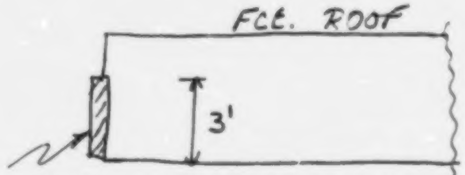
$$= \underline{1.80\ \text{MMBTU/HR.}}$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. B21 OF

DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY DATE MAR/85	CHECKED BY DATE

CALCULATION OF RADIATION LOSSES THROUGH ENDS

EACH END CAN BE MODELLED AS:



S/S CURTAINS AT CHARGE END, NOTHING AT DISCHARGE END. THE CHARGE END HAS TWO LAYERS OF CURTAINS ABOUT 4" APART. SOME SECTIONS OF CURTAIN ARE MISSING SO IN SOME AREAS THERE ARE TWO LAYERS SOME THERE IS 1 LAYER, SOME THERE ARE NONE.

ON AVERAGE ALLOW 1 LAYER OF STEEL PLATE

WITH S/S CURTAIN, THERE WILL BE VERY LITTLE ΔT ACROSS ITS THICKNESS.

STEADY STATE HEAT BALANCE OF CURTAIN (ASSUMING IT'S NOT FULLY TRANSPARENT)

HEAT RADIATED FROM INSIDE OF FCE

= RADIANT LOSS TO AMBIENT + CONVECTIVE LOSS TO AMBIENT

(ASSUME NEGLIGIBLE CONVECTIVE TRANSFER ON FCE. SIDE)

RADIATION FROM INSIDE OF FCE. PER UNIT AREA

$$\cong \frac{\sigma\left(T_{FCE}^4 - T_C^4\right)}{\frac{1}{\varepsilon_{FCE}} + \frac{1}{\varepsilon_{CURT}} - 1} = \frac{(.1714)\left(19.6^4 - T_C^4\right)}{\frac{1}{0.9} + \frac{1}{0.95} - 1} \qquad \left[T_C = \frac{{}^\circ K.}{100}\right]$$

MORE ACCURATE EQUATION THAN THAT GIVEN IN Fig, 61B

$$= (.1473)\left(19.6^4 - T_C^4\right)$$

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CALCULATION SHEET

SHEET NO. B22 OF

DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE	CHECKED B DATE

RADIANT LOSS TO OUTSIDE

$$\simeq \frac{\sigma\left(T_c^4 - 5.45^4\right)}{\frac{1}{\varepsilon_{CURT}} + \frac{1}{\varepsilon_{AMB}} - 1} = \frac{(.1714)\left(T_c^4 - 5.45^4\right)}{\frac{1}{.95} + \frac{1}{.95} - 1}$$

$$= (.1551)\left(T_c^4 - 5.45^4\right)$$

CONVECTIVE LOSS TO OUTSIDE:

ALLOW $h_c \simeq 3 \frac{BTU}{h\text{-}ft^2\text{-}°F}$

$$\therefore \quad (.1473)\left(19.6^4 - T_c^4\right) = (.1551)\left(T_c^4 - 5.45^4\right) + 3(100T_c - 545)$$

$$21{,}738 - (.1473)T_c^4 = (.1551)T_c^4 - 137 + 300T_c - 1635$$

$$300\,T_c = 23{,}510 - 0.3024\,T_c^4$$

$$T_c = 78.37 - (1.01)10^{-3}\,T_c^4$$

$$T_c \simeq 15.7 \Rightarrow \text{CURTAIN TEMP} = 15.7 \times 100 - 460$$
$$= \underline{1110\ °F}$$

HEAT LOSS FOR AREA OF 24' × 3'

$$= (.1473)\left(19.6^4 - 15.7^4\right)(24 \times 3) = \underline{(0.92)\ MMBTU/h}$$

$\therefore$ TOTAL RADIATION LOSS FROM ENDS AT PRESENT

$= 1.80$ (DISCHARGE END) $+ 0.33$ (SIDE DOORS)

$+ 0.92$ (CHARGE END)

$= \underline{3.1\ MMBTU/h}$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. S23 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY DATE MAR/85	CHECKED BY DATE

OVERALL ENERGY BALANCE FOR FURNACE:

USE ONLY NET ENERGY PICK-UP BY EACH STREAM. THEREFORE SENSIBLE ENERGY OF PIPES AT INLET & AMBIENT AIR ARE NOT SHOWN.

FOR FUEL INPUT, USE L.H.V. OF GAS — ∴ LATENT HEAT OF PRODUCTS OF COMBUSTION NOT SHOWN.

∴ FUEL INPUT = 18.5 MMBTU/H

NET ENERGY OUTPUTS (FROM PREVIOUS CALCS):

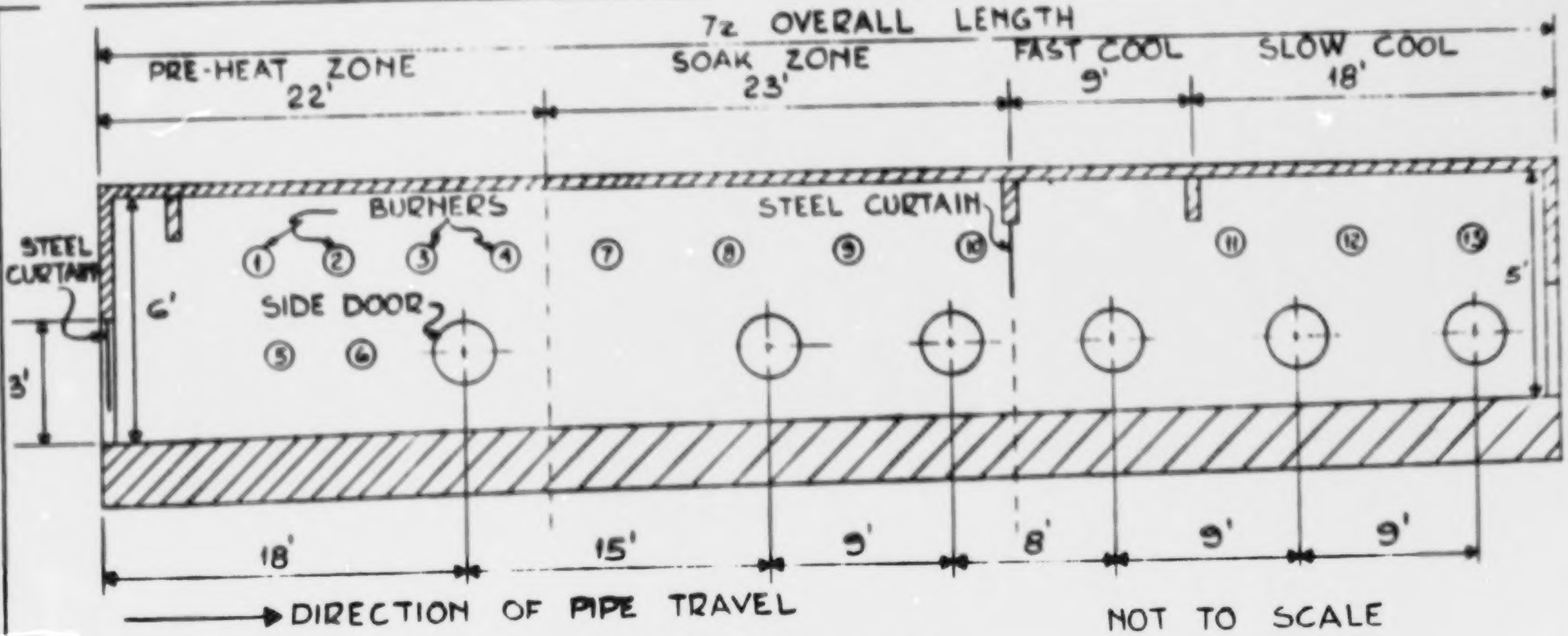
FLUE GASES	10.0 MMBTU/h	(62% OF OUTPUT)
RADTN. LOSSES THRU ENDS	3.1	(19%)
SHELL LOSSES	1.6	(10%)
NET ENERGY TO PIPES	0.7	(5%)
COOLING WATER	0.4	(2%)
CONVEYOR LOSSES	0.4	(2%)

Σ OUTPUTS = 16.2 MMBTU/h (less than 18.5 MMBTU/h)

TOTAL INPUTS & OUTPUTS IN REASONABLE AGREEMENT. FOR FURTHER ANALYSIS OF ENERGY OUTPUTS, USE 18.5 MMBTU/H TOTAL WITH % ALLOCATIONS AS ABOVE.

TOTAL ENERGY PROVIDED TO PIPES TO HEAT IT TO 1800 °F

$$= \underbrace{5\%}_{\text{ENERGY FOR MEASURED } \Delta T = 235\,°F} \times \frac{(1800 - 1100)\,°F}{235\,°F} = \underline{15\%}$$


72 OVERALL LENGTH
PRE-HEAT ZONE
22'
SOAK ZONE
23'
FAST COOL
9'
SLOW COOL
18'
BURNERS
STEEL CURTAIN
STEEL CURTAIN
① ② ③ ④ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑬
SIDE DOOR
⑤ ⑥
6'
3'
5'
18'
15'
9'
8'
9'
9'
DIRECTION OF PIPE TRAVEL
NOT TO SCALE

WEST SIDE VIEW

FURNACE WIDTH = 26' (OUTSIDE)
24' (INSIDE)

BURNER RATINGS

① - 2.0 MMBTU/H EACH
② ③ ⑤ ⑥ ⑦ ⑧ - 1.0 MMBTU/H EACH
④ - 1.5 MMBTU/H EACH
⑨ ⑩ ⑪ ⑫ - 0.6 MMBTU/H EACH
⑬ - 0.34 MMBTU/H EACH

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SCHEMATIC DRAWING OF
ANNEALING FURNACE

FIG. NO.

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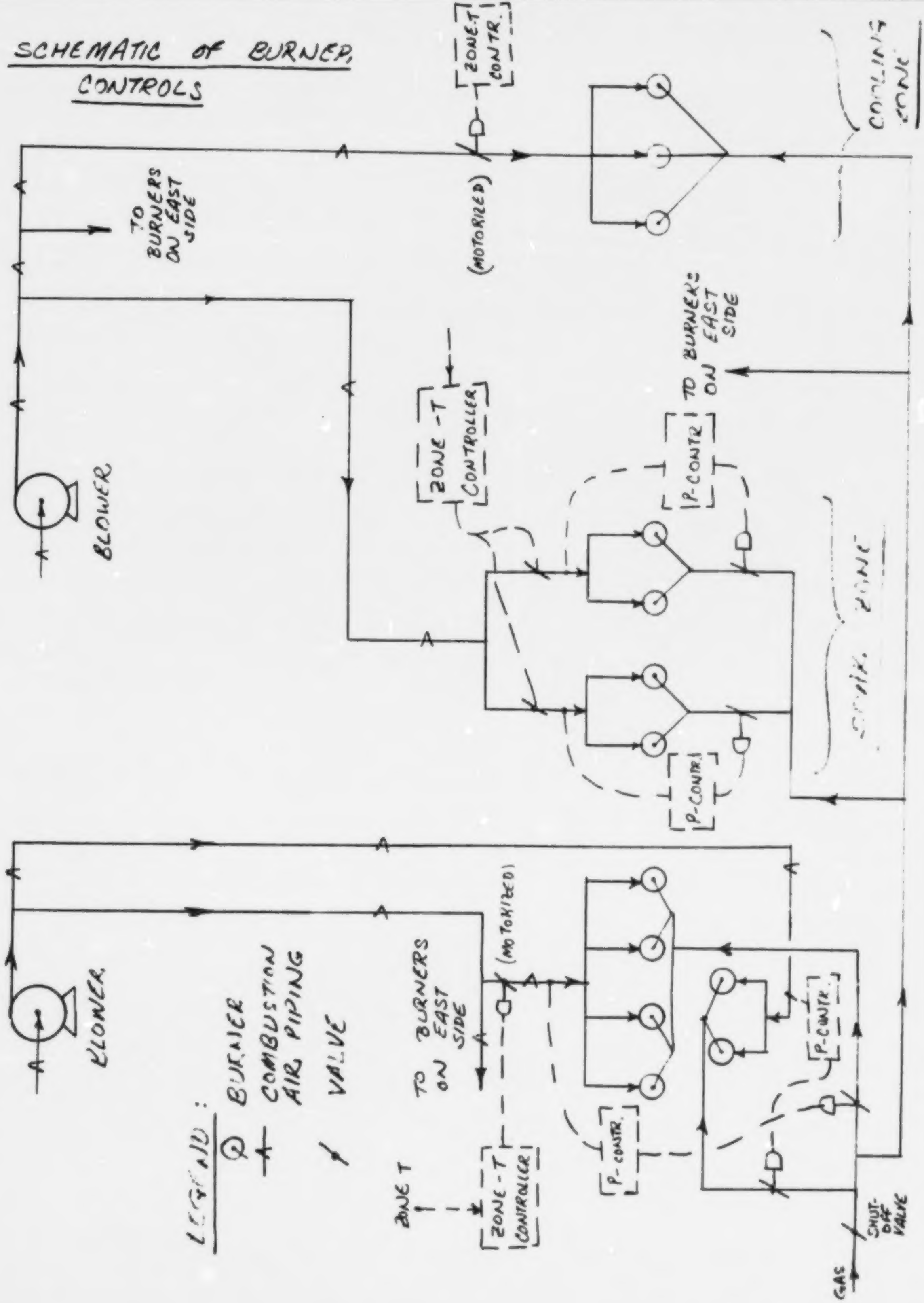
CALCULATION SHEET

SHEET NO.	DESCRIPTION	PROJ NO	MADE BY	CHECKED BY
825 OF	EMR ENERSOLVE - STANTON PIPES	9036	CK DATE APR/85	DATE

SCHEMATIC OF BURNER CONTROLS


ZONE-T CONTR.
(MOTORIZED)
TO BURNERS ON EAST SIDE
COOLING ZONE
BLOWER
ZONE-T CONTROLLER
P-CONTR
TO BURNERS ON EAST SIDE
SOAK ZONE
P-CONTR.
BLOWER
TO BURNERS ON EAST SIDE
(MOTORIZED)
P-CONTR.
P-CONTR.
ZONE T
ZONE-T CONTROLLER
SHUT-OFF VALVE
GAS
LEGEND:
BURNER
COMBUSTION AIR PIPING
VALVE
A

A - E5/73

HATCH ASSOCIATES
Consulting Engineers

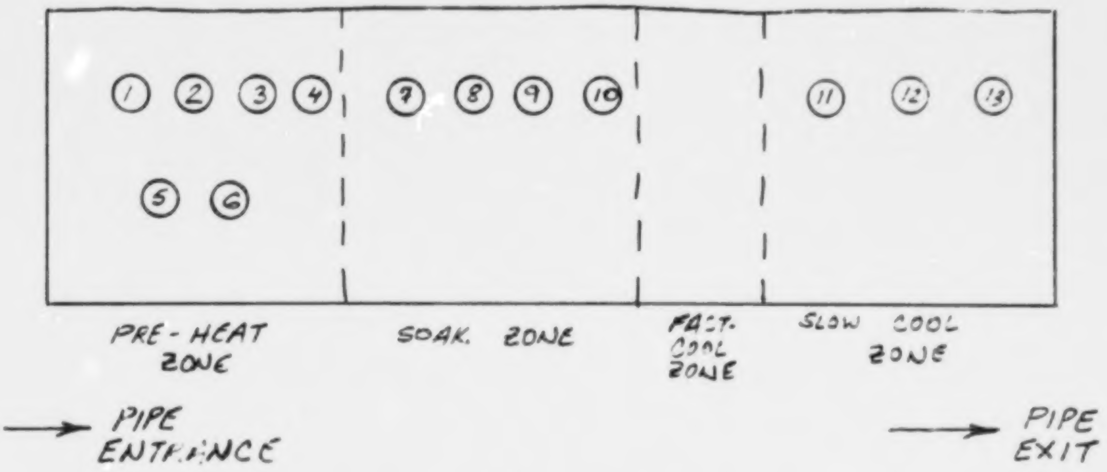
CALCULATION SHEET

SHEET N 526 o

DESCRIPTION	PROJ NO	MADE BY	CHECKE
	7036	SK, MCC DATE /85	DATE

SUMMARY OF BURNER SETTINGS

SCHEMATIC OF BURNER LOCATION:


1
2
3
4
5
6
7
8
9
10
11
12
13
PRE-HEAT ZONE
SOAK ZONE
FAST-COOL ZONE
SLOW COOL ZONE
PIPE ENTRANCE
PIPE EXIT

BURNER LOCATION	WEST SIDE (nearer offices) AIR	WEST SIDE (nearer offices) GAS	EAST SIDE AIR	EAST SIDE GAS
1 (1460-040)	2.8"W.C.	3.9"W.C.	1.0"W.C.	?
2 (1460-035)	11.0	9.5	11.8	?
3 (351L)	9.5	5.1	11.8	4.0
4 (401L)	6.0	4.0	8.5	2.5
5 (301 HTR)	28.1	19.1	(TYPICALLY OFF)	
6 (301 HTR)	26.8	24.9		
7 (351L)	5.5	4.0	11.0	4.2
8 (351L)	5.9	4.1	11.0	5.5
9 (301L)	(NOT MEASURED)		4.1	8.0
10 (301L)			4.2	?
11 (175-1-3)	USUALLY OFF			
12 (175-1-3)				
13 (175-1-2.5)				

NOTES: 1. WEST SIDE TAKES SOCKET END OF PIPE
2. ALL SETTINGS ARE AT BURNERS, MEASURED BY STANTON PERSONNEL USING A [illegible] MANOMETER.

BLOOM ENGINEERING COMPANY, INC.
Manufacturers of Industrial Gas and Oil Burners
BUFFALO DISTRICT OFFICE
P. O. BOX 158 - BUFFALO, NEW YORK 14223
HILER STATION - Telephone: (716) 874-3344
Telex: 91-9152

March 18, 1985

Hatch & Associates
2110 Claire Avenue East
Toronto, Ontario, Canada M4P 1L9

Attention: Mr. S. Kumar

Subject: Stanton Pipe Annealing Furnace
Bloom Order 960-40

Gentlemen:

In accord with your recent request, we have reviewed the burners that we have supplied for this furnace. The following tabulation shows the burner model number, air line inlet size, capacity, and air and gas pressures where these are known. We would note that this information goes back 25 years, and some of our records are incomplete with respect to the gas pressure.

BURNER NO.	AIR LINE SIZE	BTU/HR.	AIR PRESSURE	GAS PRESSURE
401-L	4"	1.5 MM	7"	---------
351-L	3"	1.0 MM	7"	---------
301-L	3"	0.6 MM	7"	2.7"
251-L	2-1/2"	0.4 MM	7"	---------
201-L	2"	0.3 MM	7"	3"
301 HTR®	3"	1.0 MM	28"	20"
175-1-2.5	2-1/2"	0.34 MM	3.25"	1.1"
175-1-3	3"	0.60 MM	3.25"	1.1"
1460-035	3"	1.0 MM	7"	2.9"
1460-040	4"	2.0 MM	7"	4"

T-10-10 Blower 2175 CFM @ 10 OSIG (≈ 10 HP @ [illegible])

We hope that this information is helpful to you.

If further identification of the burners is required, we will be pleased to visit the site with you on a paid service basis.

Sincerely,
BLOOM ENGINEERING COMPANY, INC.

L. J. Green
District Manager

LJG/jfs

APPENDIX C

LITERATURE ON RECUPERATIVE & REGENERATIVE BURNERS

CONTENTS :

	PAGES
• NORTH AMERICAN SELF-RECUPERATING BURNERS	C1 - C4
• REKUMAT RECUPERATIVE BURNERS	C5 - C8
• "REGEN" REGENERATIVE BURNERS	C9 - C12

North American
Mfg. Co.
Cleveland, OH 44105 USA

North American ⦿ Hotwork
SELF-RECUPERATIVE-BURNER †

Sheet 4838-1
4-81

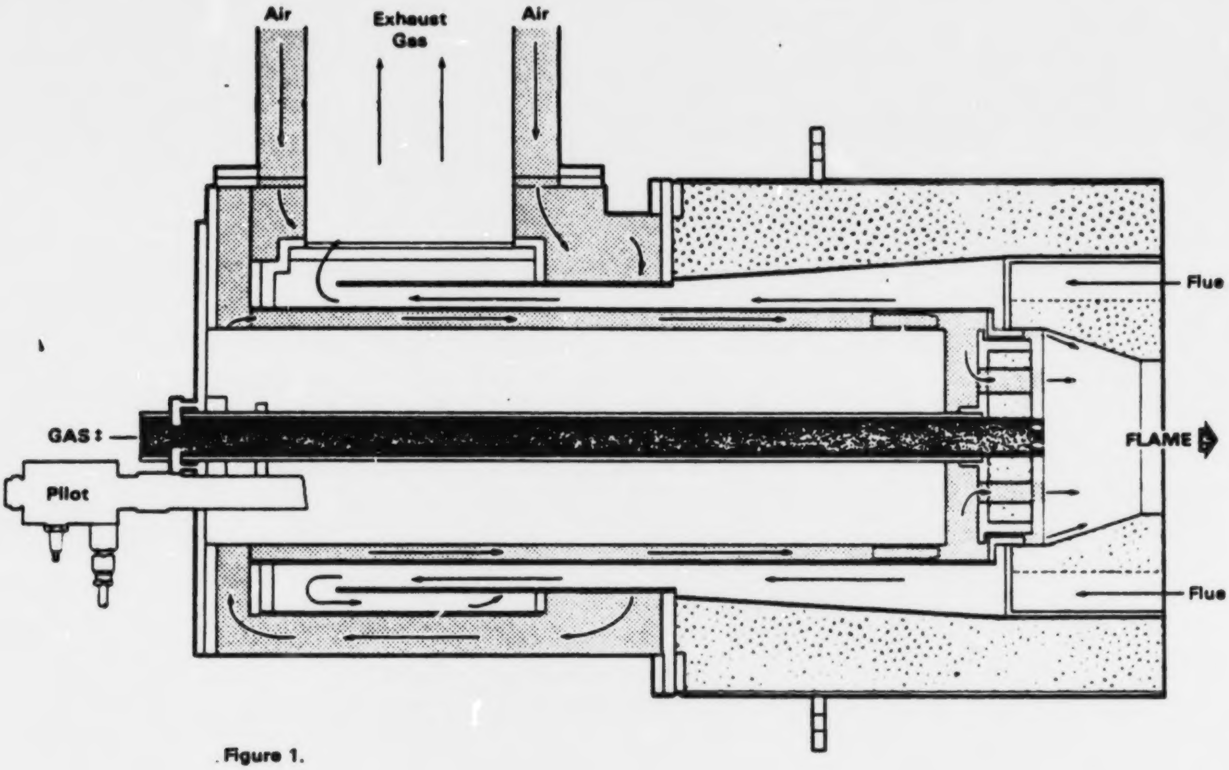


Figure 1.

SELF ⦿ RECUPERATIVE ⦿ BURNERS

FOR GASES OR LIGHT DISTILLATE FUEL OILS

INTEGRAL BURNER AND RECUPERATOR

- **Improved fuel economy**
- **Heat recovery by preheating air**
- **Simplified installation, new or retrofit**
- **No hot air piping**

---

† Applied and serviced in the USA exclusively by North American Mfg. Co., Cleveland, OH 44105 under license from Hotwork, Inc.
‡ Gas tube is replaced with a compressed air atomizer in the 5898 light oil burner.

C2

SELF – RECUPERATIVE – BURNERS

HOW S-R-BURNERS WORK

Furnace gases exit through 8 slots in a ring around the burner nose. The nozzle exit velocity of the burner is on the order of 300 fps, so there is no interference or short-circuiting between the flame and the flues. The flue gases pass counterflow through a concentric heat exchanger, heating incoming combustion air on *both* walls of their passage. (Refer to Figure 1.) Flue gases then reverse, transmitting more heat to the wrap-around combustion air plenum. Final heat recovery takes place as the hot gases are exhausted through additional concentric counterflow heat transfer surfaces on their way to the eductor and final discharge.

Cold incoming air traverses the two recuperator sections in succession, completely surrounding the hot waste gas elements for (a) maximum exchanger effectiveness, and (b) personnel protection from hot surfaces. It then passes along the inside wall of the hottest waste gas section, and finally exits through an array of hot air nozzles. The air streams mix with the fuel stream inside the high temperature refractory nozzle, which ejects the mixing stream at high velocity.

Thermal expansion within the burner/recuperator is accomodated by patented features. These design features produce larger air openings at higher temperatures, partially compensating for the lower-density preheated air.

Self-recuperative-burners should not be used for dryout operations, which might result in condensation within the recuperator. Sulfur-bearing fuels can cause corrosion problems, necessitating special materials of construction.

HEAT RECOVERY

In fuel-fired furnaces, considerable amounts of waste heat are exhausted through the stacks. In a furnace operating at 1100 F, for example, 32% of the heat from the fuel is lost in this way; at 1900 F, 52%; and at 2500 F, 68%.

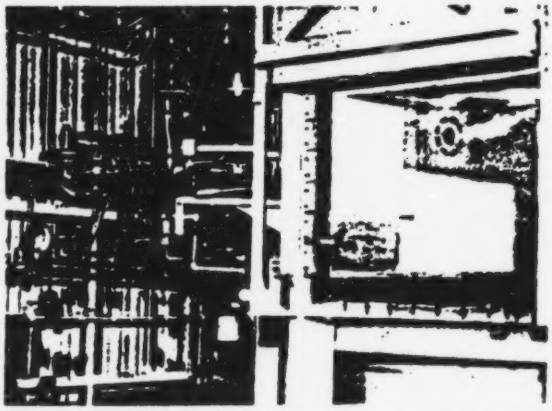


Figure 2. Rotary forge furnace equipped with self-recuperating gas burners.

One way of recovering this heat in a furnace has been to use recuperation, where the outgoing exhaust gases heat the incoming combustion air supply to the burners. Centralized recuperators require insulated hot air piping to prevent heat loss. In addition a centralized recuperator requires costly manifolding of the furnace exhaust stacks. They also pose some control problems, particularly on batch furnaces, because of the change in air density with increasing temperature.

The North American ◉ Hotwork self-recuperative-burners provide heat recovery from exhaust gases, within the burner, eliminating insulated air piping and stack manifolding. No hot air control valves are required.

S-R-B BENEFITS

The fuel saving from air preheating depends on how much heat is transferred from the exhaust gases to the combustion air (directly related to the exhaust gas temperature). Experience from operating installations indicates that air preheat temperature will be about 35% of the furnace operating temperature in degrees Fahrenheit. (See Figure 3.)

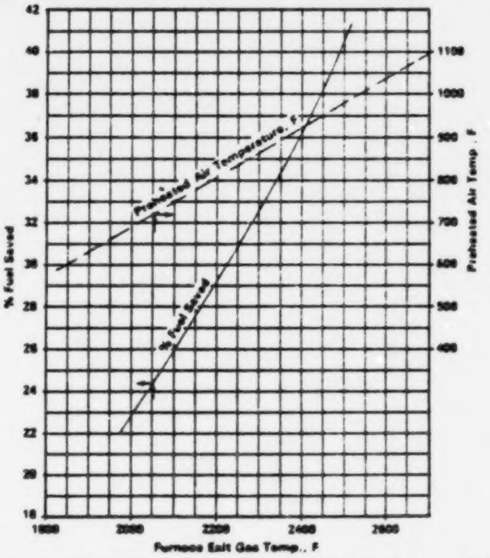


Figure 3. Estimated fuel savings and performance at high fire rating.

In addition to energy savings by the direct reduction of flue gas loss, further savings may be achieved by:

(1) The eductor used to pull waste gas through the burner's integral recuperator effectively controls the furnace pressure. This gives the option of maintaining a slightly positive furnace pressure which would prevent infiltration of ambient air, thus further reducing stack loss and improving temperature uniformity.

(2) The higher flame temperature resulting from air preheat increases the rate of heat transfer to the load. This may allow an increased furnace production rate.

SELF – RECUPERATIVE – BURNERS

Applications for Self-Recuperative-Burners

Forge furnaces, Reheat furnaces
High temperature heat treat furnaces
or wherever:

1.) Flue gas temperatures are high
2.) Residence time at high temperature is long
3.) Control of furnace pressure can prevent ingress of cold air.

Successful installations include:

- 90 Ton Forging Furnace

  A 28′ long car bottom furnace has been retrofitted with eight 1.5 million Btu/hr self-recuperating burners. Fuel savings compared with a similar conventionally fired furnace adjacent to the converted unit indicate about a 1 year payback.

- Plate Heating Furnaces

  Two large plate heating furnaces, used in the production of hot spun dished ends, showed fuel savings of 25% when retrofitted with five self-recuperative burners.

- Parts Forging Furnace

  A box furnace equipped with 2 self-recuperative-burners and utilizing other design modifications has provided fuel savings, while increasing production rate, improving temperature uniformity, and requiring less maintenance.

Turndown

As with all metallic recuperators, temperature limits must not be exceeded. To accomplish this, the system turndown is controlled so that the combustion air flow rate never falls below what is required to keep the recuperator sufficiently cooled. Typically, 5:1 turndown is available at furnace temperatures up to about 2400 F. Turndown may be limited at higher furnace temperatures.

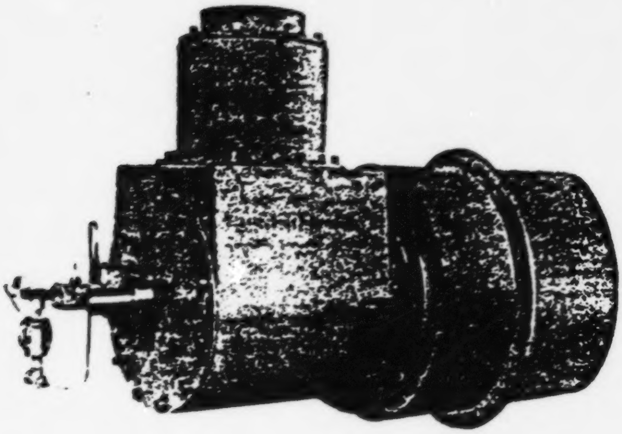


Figure 4. A self-recuperative-burner has a recuperator (heat exchanger) within its body. The cold combustion air connection is not visible in this view (on far side of vertical cylinder). The flue gas eductor and eductor air connection are not shown. Details of the pilot apparatus may vary from those illustrated.

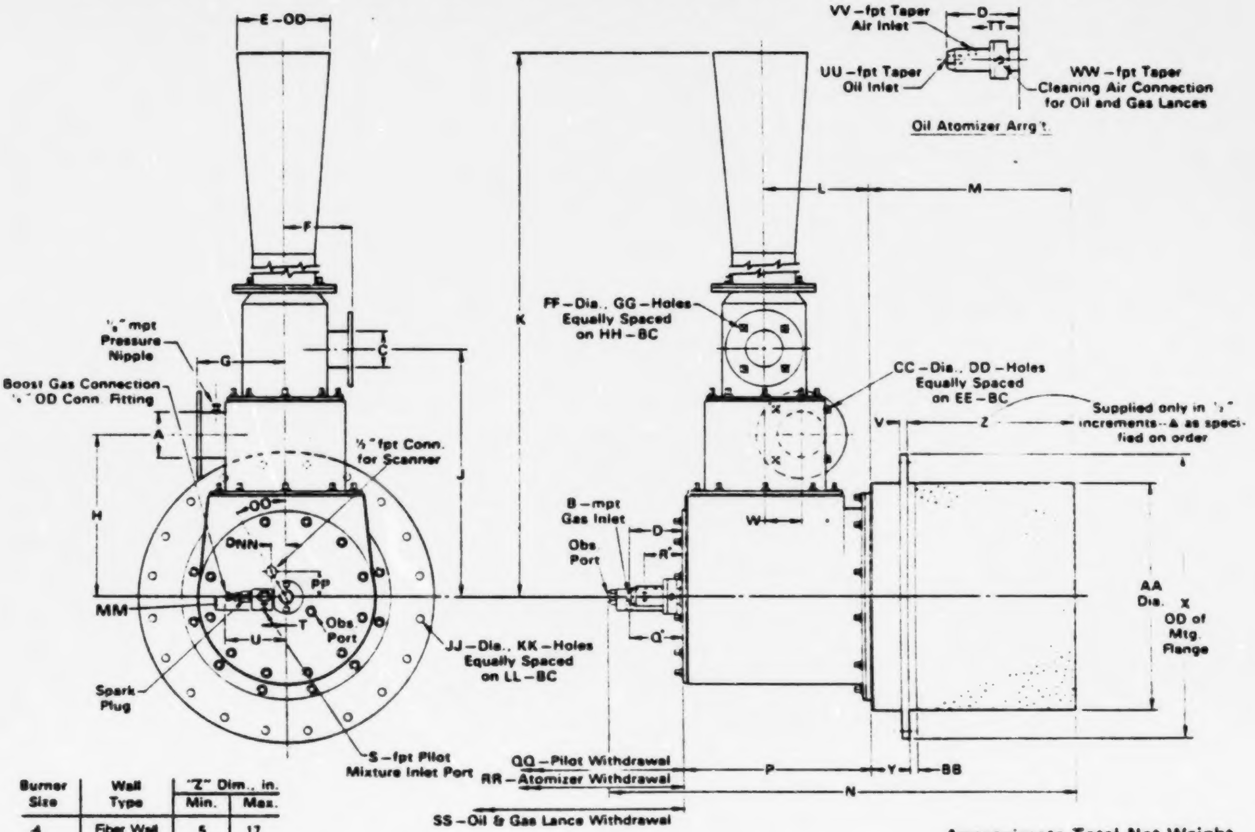
CAPACITIES AND MAXIMUM[§] AIR REQUIREMENTS

	4898-4 5898-4 0.5 million Btu/hr	4898-6 5898-6 1.0 million Btu/hr	4898-7-A 5898-7-A 1.5 million Btu/hr	4898-7-B 5898-7-B 2.5 million Btu/hr
Combustion Air	5000 cfh @ 27″wc §	10 000 cfh @ 27″wc §	15 000 cfh @ 27″wc §	25 000 cfh @ 27″wc §
Eductor Air	12 000 cfh @ 20″wc §	18 000 cfh @ 20″wc §	27 000 cfh @ 20″wc §	45 000 cfh @ 27″wc §
Pilot Air	350 cfh @ 27″wc	350 cfh @ 27″wc	350 cfh @ 27″wc	350 cfh @ 27″wc
Pilot Gas	50 cfh @ 8″wc	50 cfh @ 8″wc	50 cfh @ 8″wc	50 cfh @ 8″wc
Main Gas	500 cfh @ <1″wc	1000 cfh @ <1″wc	1500 cfh @ <1″wc	2500 cfh @ < 1″wc
Cleaning Air	300 cfh @ 12″wc	300 cfh @ 12″wc	300 cfh @ 12″wc	300 cfh @ 12″wc

§ Values shown are required for furnace tamperatures in the range of 2400-2500 F. Lower furnace temperatures reduce air pressure requirements.

c4.

SELF-RECUPERATIVE-BURNERS


E-OD
F
⅛" mpt Pressure Nipple
G
C
Boost Gas Connection ¼" OD Conn. Fitting
A
½" fpt Conn. for Scanner
H
J
K
OO
NN
PP
MM
T
U
Obs. Port
Spark Plug
S-fpt Pilot Mixture Inlet Port
JJ-Dia., KK-Holes Equally Spaced on LL-BC
VV-fpt Taper Air Inlet
D
TT
UU-fpt Taper Oil Inlet
WW-fpt Taper Cleaning Air Connection for Oil and Gas Lances
Oil Atomizer Arrg't.
L
M
FF-Dia., GG-Holes Equally Spaced on HH-BC
CC-Dia., DD-Holes Equally Spaced on EE-BC
Supplied only in ½" increments-▲ as specified on order
V
Z
W
B-mpt Gas Inlet
D
Obs. Port
R
Q
AA Dia.
X OD of Mtg. Flange
QQ-Pilot Withdrawal
RR-Atomizer Withdrawal
SS-Oil & Gas Lance Withdrawal
P
Y
BB
N

Burner Size	Wall Type	"Z" Dim., in.	
		Min.	Max.
-4	Fiber Wall	5	17
	Rigid Wall	9	17
-6	Fiber Wall	5	17
	Rigid Wall	9	17
-7-A	Fiber Wall	5	18
	Rigid Wall	9	18
-7-B	Fiber Wall	5	19½
	Rigid Wall	9	19½

fpt = female pipe thread (American Standard)
mpt = male pipe thread (American Standard)

Approximate Total Net Weight

4898/5898-4	500 pounds
4898/5898-6	650 pounds
4898/5898-7-A	800 pounds
4898/5898-7-B	1100 pounds

Dimensions in inches. All dimensions except mounting dimensions are for estimating purposes only.

Burner Designation	A	B	C	D-OIL	D-GAS	E	F	G	H	J	K	L	M	N	P	Q*	R*	S	T	U	V	W
4898 & 5898-4	2	¾	2	5⅜	3⅞	6	5¾	6	$9\frac{13}{16}$	$21\frac{7}{16}$	$56\frac{11}{16}$	$8\frac{11}{16}$	17⅞	37⅞	12⅞	5⅛	3⅜	½	1¾	5⅜	⅝	$1\frac{1}{16}$
4898 & 5898-6	3	¾	3	5⅜	4	7	6½	7	$13\frac{1}{16}$	$22\frac{3}{16}$	64⅝	$8\frac{7}{16}$	17½	41	16½	5⅛	3⅜	½	1¾	5⅜	⅝	3
4898 & 5898-7-A	4	1	3	5⅜	$3\frac{15}{16}$	9	6½	8½	15¾	24⅛	76⅛	$10\frac{1}{16}$	18⅝	44	$18\frac{1}{16}$	5⅛	$3\frac{11}{16}$	½	$2\frac{3}{16}$	$5\frac{13}{16}$	⅝	3½
4898 & 5898-7-B	4	1½	4	5⅜	$3\frac{15}{16}$	11½	8	11¾	20	29⅞	96⅜	$10\frac{1}{16}$	20	47⅛	$20\frac{9}{16}$	5⅛	$3\frac{11}{16}$	½	3	6⅝	⅝	4⅞

Dimensions in inches. All dimensions except mounting dimensions are for estimating purposes only.

Burner Designation	X	Y	Z	AA	BB	CC	DD	EE	FF	GG	HH	JJ	KK	LL	MM	NN	OO	PP	QQ	RR	SS	TT	UU	VV	WW
4898 & 5898-4	22¼	▲	▲	16	⅜	—	—	—	—	—	—	⅜	20	20	1¼	1	30°	1¾	33¼	34¾	34¾	$3\frac{7}{16}$	⅛	⅛	⅜
4898 & 5898-6	26¼	▲	▲	20	⅜	$\frac{11}{16}$	4	5¾	$\frac{11}{16}$	4	5¾	⅜	20	24	1¼	1⅜	30°	2⅜	35¾	37¼	37¼	$3\frac{7}{16}$	⅛	¼	⅜
4898 & 5898-7-A	28¼	▲	▲	22	⅜	$\frac{11}{16}$	4	7	$\frac{11}{16}$	4	5¾	⅜	20	26	1¼	1⅜	30°	2⅜	37½	39	39	$3\frac{7}{16}$	⅛	¼	⅜
4898 & 5898-7-B	36¼	▲	▲	30	⅜	$\frac{11}{16}$	4	7	$\frac{11}{16}$	4	7	1	20	34	1¼	$1\frac{15}{16}$	45°	$1\frac{15}{16}$	40½	42	42	$3\frac{7}{16}$	¼	⅛	⅜

▲ Supplied only in ½" increments as specified on order. * Applies to Pilot.

Burner includes:

A complete burner includes mounting plate with tile, jacket and star, spark ignited pilot assembly, eductor and either gas lance or oil atomizer.

Order must specify:

4898-__(size) Gas Burner or 5898-__(size) Oil Burner

Examples: 4898-4 Gas Burner complete; 5898-7-A Oil Burner complete

In addition specify: Furnace wall construction (hard brick, blanket, etc.) and Z dimension (thickness of wall plus shell) to nearest ½".

C5

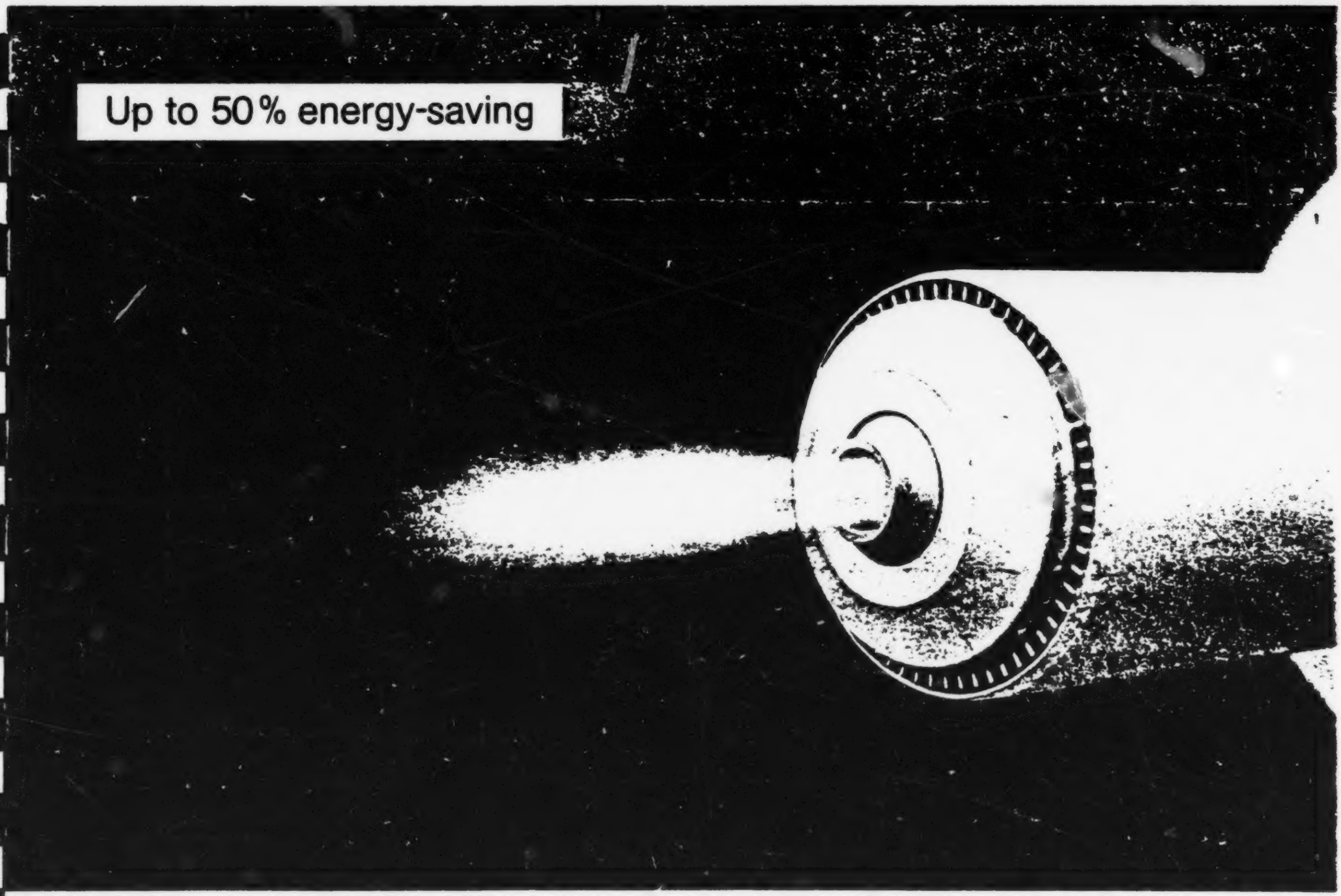
REKUMAT®

GAS BURNER WITH HEAT RECOVERY

design by Dr.-Ing. J. Wünning

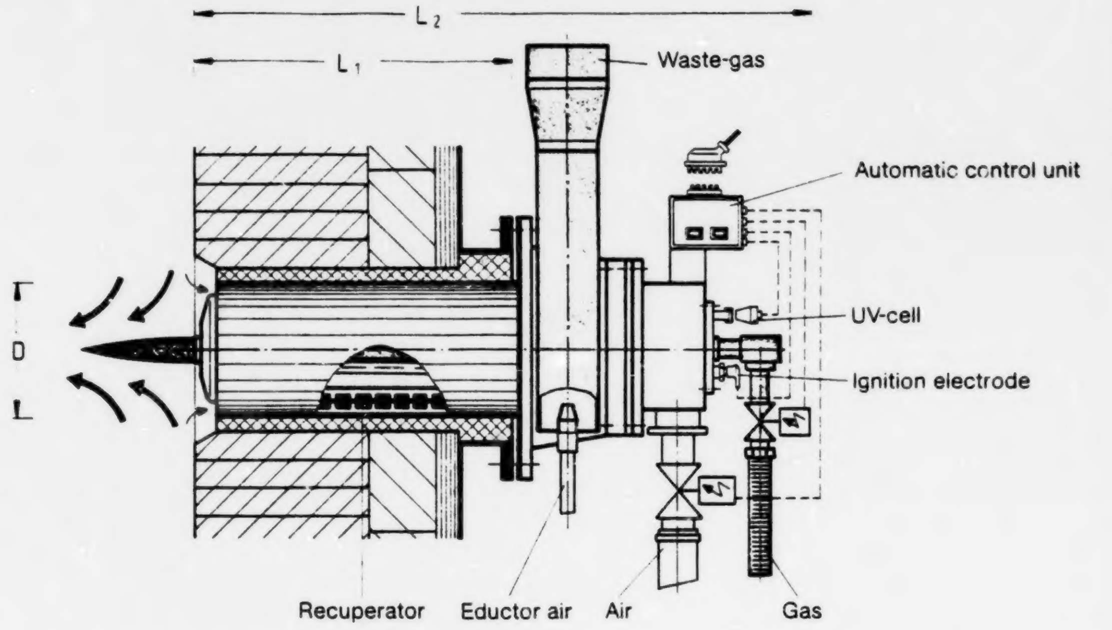
3 modern burner conceptions are combined in the REKUMAT

- **IMPULSE BURNER**
- **HIGH PERFORMANCE RECUPERATOR BURNER**
- **AUTOMATIC BURNER**



for the steel, metal, chemical and ceramic industries. Temperature range: 400 °C to 1.300 °C

WS Wärmeprozesstechnik GmbH



IMPULSE BURNER

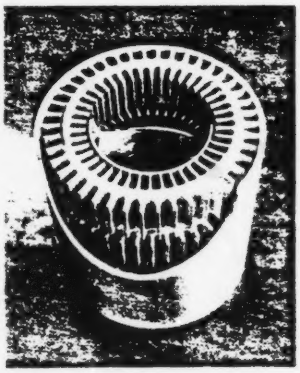
- The REKUMAT is a true impulse or high velocity burner where the excess temperature of the combustion gases is rapidly reduced. REKUMAT burners create a strong circulation flow within the furnace if burners are properly positioned. The high mixing energy of the flame jet reduces the level of pollutants.
- Even in the low temperature range the burner fires reliably at full load during ON-OFF control operation.
- The replaceable ceramic combustion chamber is varied to suit the velocity of the combustion gases (normally 50 to 100 m/s). With a fully closed furnace chamber the outside noise level is low.

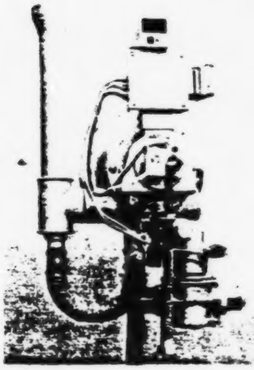
HIGH PERFORMANCE RECUPERATOR BURNER

- The ribbed-type recuperator, made from cast CrNi steel and suitable for operating at waste-gas temperatures of up to 1.300 °C, is mainly situated within the furnace wall, thus holding external heat losses to a minimum.
- At each burner 80% to 100% of the waste-gas is drawn back through the recuperative burner by means of an integrated air jet eductor. The furnace pressure can be regulated.
- Air preheating at nominal load ranges from 55% to 65% of the waste-gas temperature at point of entry into the recuperator, e.g. approximately 700 °C air preheating at a furnace temperature of 1.100 °C.

AUTOMATIC BURNER

- The low waste-gas temperature and the insulated burner head make it possible to mount the control elements for gas, combustion air an waste gas together with the automatic ignition and monitoring system on the burner.
- This ready to connect, pre-piped and pre-wired burner unit is adjusted on our test stand before delivery.
- Complete exchange of burner units during normal operation of the furnace is possible.





BURNER SIZES, SELECTION, ARRANGEMENT

Three standard sizes are available for natural gas, LPG and coke oven gas (lean gases on request)

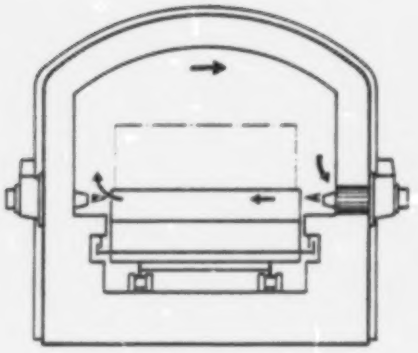
Burner size		1	2	3
Combustion air (80 mbar)	Nm^3/h	40	80	160
Eductor air (80 mbar)	Nm^3/h	60	120	240
Equivalent flow of natural gas (n = 1,1)	Nm^3/h	4	8	16
Capacity max.*	kW	40	80	160
Gas pressure at the burner	mbar	50	50	60
Main dimensions:				
Diameter D (approx.)	mm	140	190	250
Installation length L1 (approx.)	mm	430	430	430
Total length (approx.)	mm	950	1.000	1.100

* According to type of gas and air ratio (n). A higher capacity is only possible at a considerably lower preheating rate if a reasonable size is to be maintained.

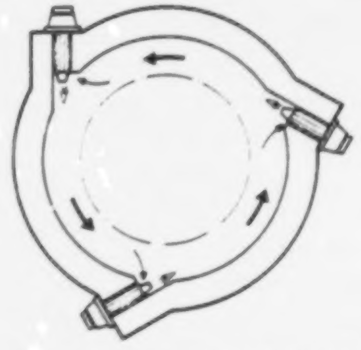
The selection of burner size and number of burners depends on the required connected load of the furnace or furnace zone, the heat demand ratio and desired temperature uniformity.

The burners are normally arranged tangentially to the load, retort or crucible to produce the required circulation flow (see examples).

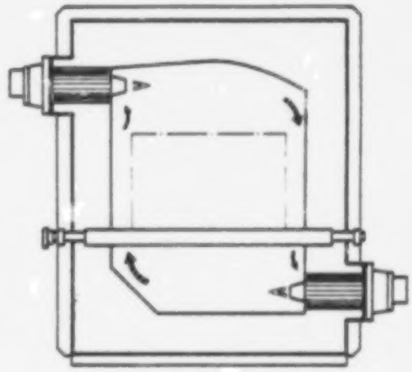
REKUMAT burners are adaptable to various radiant tube systems.



Bogie hearth furnace



Pit type, retort or crucible furnace

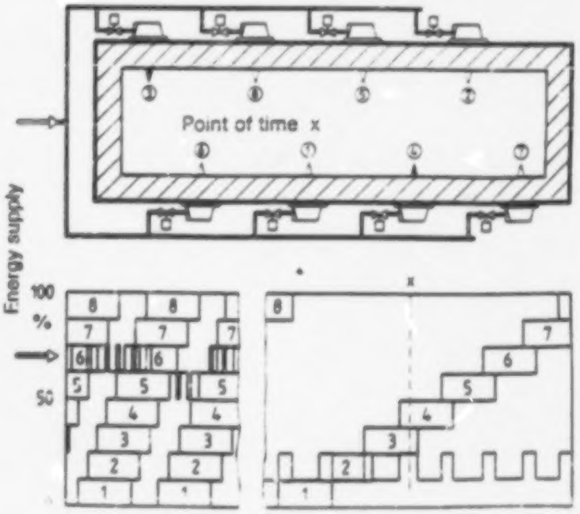


Roller hearth furnace

CONTROL AND TEMPERATURE UNIFORMITY

The advantages of high velocity burner technology can best be realized by ON-OFF regulation directly controlled by digital computer. The volume flow for gas, combustion air and waste-gas are preset at each burner according to the required operating conditions, thus the expense for mixture regulation can be avoided.
Only in special cases would HIGH/LOW-regulation be used.

Circulating or sequence firing, provides a quasi continuous control which also avoids pressure blasts in the gas and air-network. A condition is, however, that the connected load of a zone is distributed over a sufficiently large number of burners. This number increases with demands for higher temperature uniformity and control ratio. If oxigen-poor atmospheres are requested, the low fire demand must exceed the capacity of a single burner and the furnace must be sealed properly.



With REKUMAT heating a temperature uniformity of ± 5 K has been achieved in chamber [illegible] and bogie hearth furnaces

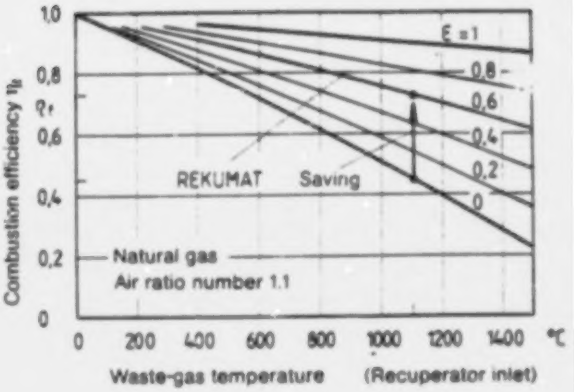
ENERGY SAVING

The combustion efficiency η_f, defined by waste-gas losses and fuel energy flow, rapidly drops with increasing waste-gas temperature (see fig.). Waste-gas heat can be recovered by combustion air preheating. This recovery is proportional to the degree of air preheating ε, which represents the most important measure for evaluating recuperator burners. The degree of air-preheating for the REKUMAT ranges from 55% to 65%. The percentage saving is a result of the ratio of the efficiencies, characterized by the following formula

$$\text{Saving in \%} = \left(1 - \frac{\eta_{f\,\text{comparsion}}}{\eta_{f\,\text{REKUMAT}}}\right) \times 100$$

Data shown in figure refer to the combustion of natural gas with an air ratio number of n = 1.1, and are also approximately correct for coke-oven gas and LPG.

The example shows that at 1.100 °C without air preheating, an efficiency of η_f 45% results, whereas with the REKUMAT 72.5% is achieved (ε = 0.6), at an effective preheat temperature of 670 °C. According to the above formula, this saving amounts to 38%. With an air ratio number of n = 1.2 this saving increases to 42%.



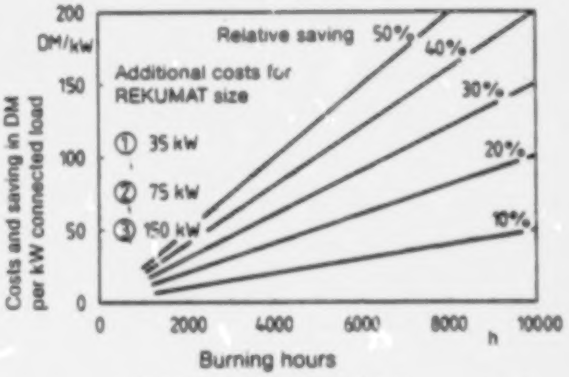
PROFITABILITY

To evaluate the increased profitability, possible by use of REKUMAT burners in place of other heating systems, it is necessary to compare the levels of efficiency achieved and the total operating costs. This is shown by the following examples and accompanying diagram, which expresses German Marks (DM) per kW connected load as a function of actual burning hours.

Case A

REKUMAT heating compared to other high velocity burners operating without air preheating, but including installed control elements as well as burner and flame controls.

The diagram shows the additional costs for operating of the three different burner sizes. At a temperature of 1.100 °C, approximately 40% saving is possible with the REKUMAT, which means a payback time for a REKUMAT burner, size two, of 3.000 burning hours (approx. equivalent to one-year, 3-shift operation).



Gas-price DM 0.50 per Nm3

Case B

REKUMAT heating compared with a burner system using a central recuperator or other recuperator type burners, at a furnace temperature of 1.100 °C.

	REKUMAT	Comparsion
Air preheating ratio	0.6	0.4
Preheating temperature	600 °C	400 °C
Efficiency	77.5%	70%
Saving	10%	

Extra costs of DM 20.– per kW connected load are recovered after 4.000 burning hours.

Case C

Conversion of a furnace with 7.500 kW connected load for a process temperature of 1.100 °C to REKUMAT heating.

The conversion costs of DM 150.– per kW connected load are amortized over a period of 8.000 burning hours as a results of a 40% saving in operating costs.

Several thousands of REKUMAT burners are already in use in various furnace types

WS
Wärmeprozesstechnik GmbH

7015 Korntal-Münchingen 1
Postfach 1428
Hermann-Wissmann-Weg 35

Telefon 07 11/83 66 51
oder /83 77 24
Teletex 7 111 351

the reGen

REGENERATIVE BURNER

The reGen Regenerative Burner is a high air preheat ceramic burner close coupled to a compact fast cycle ceramic regenerator. Applied in pairs to a fired chamber, together with a purpose made reversing valve system, the reGen burner offers to the user the benefit of exhaust heat recovery potential considerably in excess of the recuperator or recuperative burner, without the disadvantages of short heat exchanger life associated with industrial environment recuperation.

Fuel savings, over cold air, in the range of 40% at 1800°F to 60% at 2500°F can realistically be achieved with commensurately short payback. The reGen is insensitive to its environment - high waste gas temperatures, corrosive and dirty exhaust gases are within its potential to handle without operational difficulties.

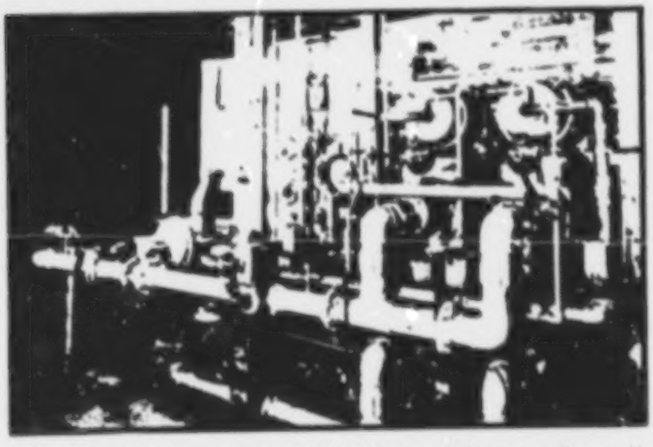
reGen has been extensively tested in both laboratory and field application. Its first industrial use (in January 1983) was the firing of a 2550°F glass melting furnace - one of the most demanding duties possible for a compact heat recovery package. In the first year of commercialization, 122 burners were installed, with a fuel saving potential in excess of 200 million BTU/hr.

90% HEAT EXCHANGE EFFECTIVENESS

The reGen unit has the ability to capture 75% of the heat content of the waste gas from a furnace and transfer it to the combustion air, a heat exchange effectiveness of 90%.

The air preheats which can be achieved with metallic recuperators and recuperative burners are limited to the maximum service temperature of the metal interface between the exhaust gases and combustion air. Metal recuperator effectiveness therefore rarely exceeds 40% which means that 60% or more of the available heat in the flue gases remains unrecovered.

Ceramics, while not suffering the temperature limitations of metals, prove difficult to fabricate into suitable recuperators and are highly susceptible to failure under tensile stress, producing cracks and leakage.



A 2550°F soda-lime glass tank fitted with one reGen unit in January 1983 is demonstrating a 22% saving over the recuperative system that it replaced. Photograph by courtesy of Translucent Glass Ltd., Wakefield, England.

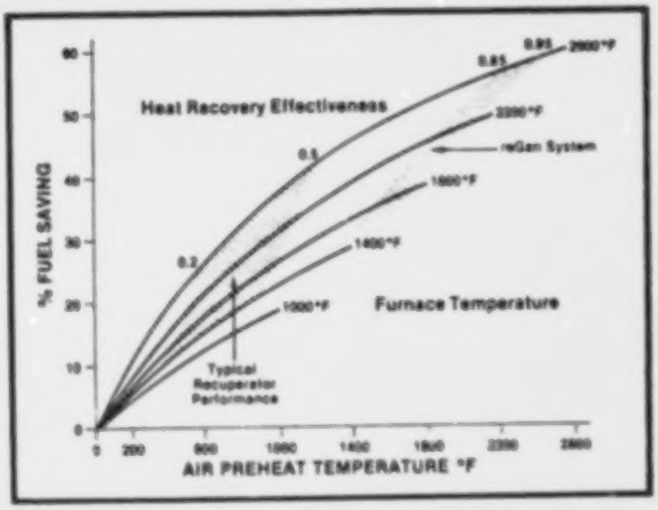
BETTER THAN RECUPERATION?

Without a doubt!

PERFORMANCE

The chart below compares the heat recovery effectiveness and fuel saving potential of the reGen with recuperation. The area indicated between 20 and 50% effectiveness represents the performance of typical available heat recovery equipment - 20 to 40% for metal recuperators, 40 to 50% for ceramic recuperators.

The area at 85 to 95% is the regime of operation of the reGen Regenerative Burner. The heat recovery performance of the reGen is such that it operates at around 90% of the theoretical maximum of any heat recovery device - a true effectiveness of between 85 and 95%. It provides air preheats in excess of 85% of the process temperature with commensurately low waste gas temperatures.

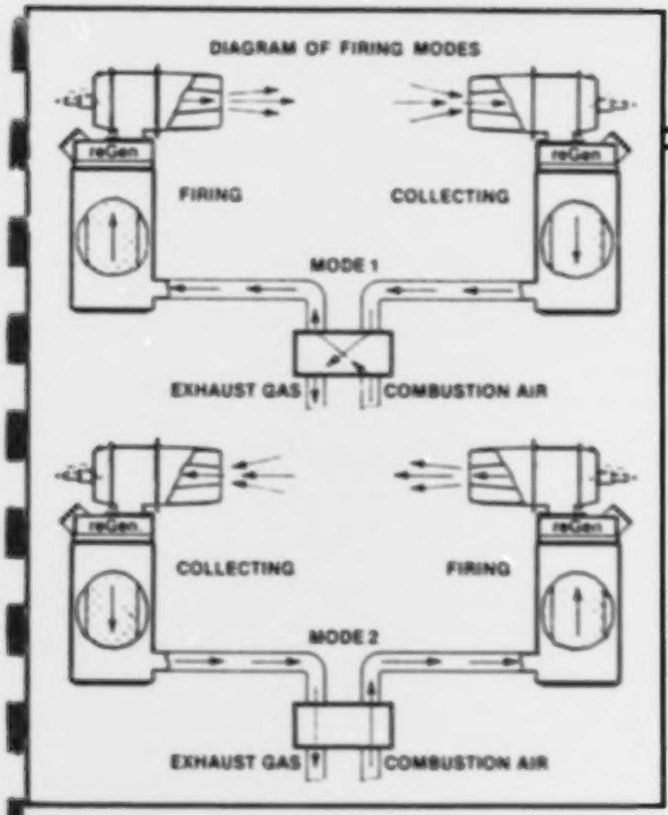


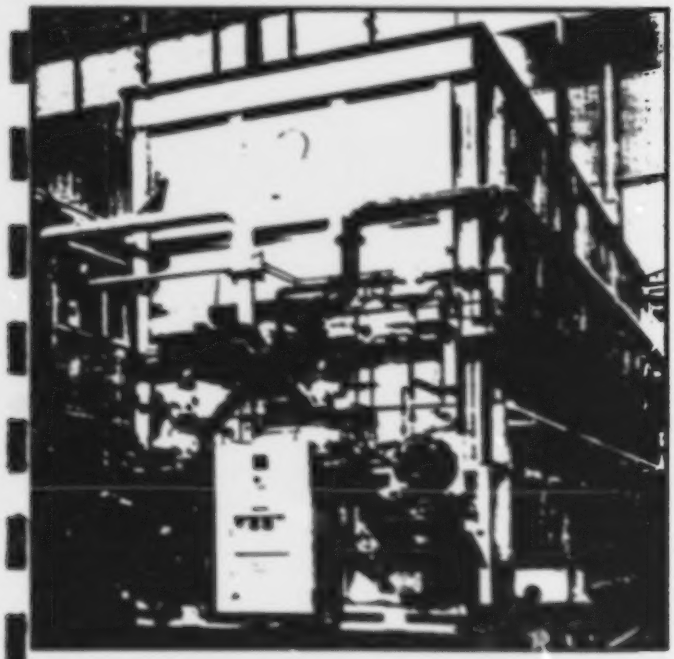
INSENSITIVITY TO ENVIRONMENT

In addition to the major advantage of higher fuel savings, the basic design and operating characteristics of the reGen provide lack of sensitivity to its operating environment. There are no boundaries between air and waste gas streams to be maintained against leakage and the materials have been chosen to withstand the corrosive effects of exhaust gas borne volatiles.

The reGen has proven capability of operation with dirty gas streams. The regenerator packing can be easily cleaned of any dirt or condensed fouling - it can be dropped out of the base of the regenerator of an exhausting burner, cleaned and replaced through the top.

The Translucent Glass installation (shown in adjacent photograph) demonstrates this property exceptionally well. The exhaust gas is heavily contaminated with volatiles and batch carry-over. Despite these contaminants, the reGen has proven to be an extremely efficient firing system. The regenerators are kept at their peak of performance by a monthly cleaning, taking about 50 minutes, without shutting down the system.





One of 9 four stack in-line coil annealers of [illegible]0 Tonne capacity which have been retrofitted with reGen systems to replace the original cold air fired "hot-spot" type burners. Photograph by courtesy of British Steel Corporation.

HOW IT WORKS

While one burner fires using cold air fed to the base of its regenerator, waste gas is drawn through the other burner and down into its associated regenerator to preheat the packing and then exhausted to the atmosphere.

When the regenerator being heated is sufficiently charged the reversing system operates, cold air flows into the base of the newly heated regenerator and is preheated on its way to the burner, and the previously cooled regenerator is again reheated by the exhaust gas drawn down through its burner from the furnace.

This reversal process proceeds automatically, independent of any of the normal furnace controls, based on a combination of time and exhaust gas temperature at the base of the regenerator.

SYSTEM HARDWARE

The burners are applied in pairs but each pair functions independently and may thus be considered as a conventional burner.

Suction is required at the base of the regenerator to overcome the resistance of the packing to exhaust gas flow. The low temperature of the waste gas from the reGen allows use of conventional cold combustion air fans for this duty.

The low exhaust temperatures also allow the waste gas to be handled in uninsulated piping. Mild steel pipe with screwed fittings is in use on a 2550°F glass tank system.

Air and exhaust flows for the unit are controlled by tandem linked valves driven from the process temperature controller. A fine trim on exhaust flow is provided by a motorized valve mounted on the suction fan outlet, controlled from furnace pressure.

Fuel reversal is accomplished by solenoid valves. Proof of closure switches on these valves are interlocked with the reversing system.

Fuel/air ratio control is by cold side metering and can be achieved with any standard flow related system. A cross loaded ratio regulator operating from a signal proportional to an air orifice plate differential is recommended for simplicity and reliability.

Trim and control valves in the exhaust line may be conventional cold air valves. The exhaust fan is protected against over temperature conditions by mounting temperature sensors on the fan case and arranging to drive the firing rate to low fire and close the exhaust trim valve on rise above desired limit.

Simple relay, timer and temperature control logic provides the interfacing for the reGen controls with conventional furnace, combustion and flame protection controls.

For larger applications and those requiring sequencing of reversal between pairs of burners, dedicated PC's can be used for the reversal control.

Furnace Temp.°F	Combustion Efficiency %(cold air)	reGen Air Preheat Temp.°F (average)	reGen Waste Gas Temp.°F (average)	reGen Combustion Efficiency %(average)	reGen Fuel Saving over Cold Air Operation %
1800	46	1700	300	79	42
2000	42	1800	320	79	47
2200	37	1980	360	77	52
2370	32	2140	390	75	58
2550	26	2370	430	74	65

FEATURES

The burner is capable of combustion of any typical rich fuel with air preheats up to 2400°F. It also acts as a flue port and exhaust way for exhaust gases up to 2550°F when in exhaust mode.

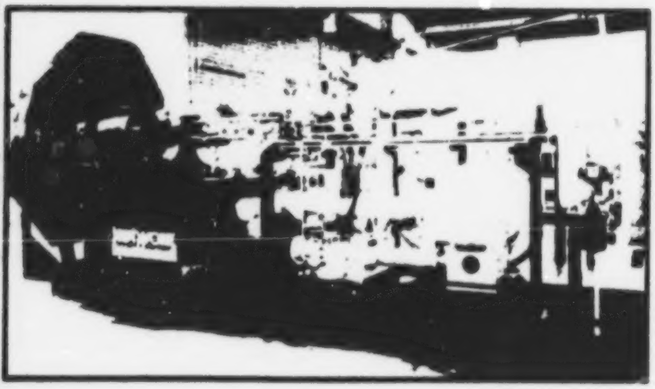
The compact regenerator accepts exhaust gas up to 2550°F and can heat air to 2400°F. Final exhaust temperature from the regenerator operating at these levels would be around 450°F.

The table above gives actual values of air preheat for various furnace temperatures. It also shows the high level of fuel savings achieved by the reGen - these savings based on energy recovery alone.

The automatic reversing system connecting a pair of regenerators includes the valve needed to re-direct the flows of air and waste gas complete with its actuator and a logic circuit using waste gas temperature and time inputs to determine the actual reversing sequence.

Close coupling of the burner to an individual regenerator and enabling the burner to act as an exhaust port eliminates the need for hot valving operating at furnace exhaust gas temperature. The reGen reversing valve is located at the cold end of the regenerator.

The need to extinguish and ignite burners at each reversal is eliminated by incorporating a standby system into the burner design which allows the burner to fire at 1 to 3% of maximum rated capacity while in the exhaust mode.



This AOD vessel heating system includes a purpose built 6 million BTU/hr reGen unit with rectangular regenerators of elongated plan view to aid weight distribution on the carriage on which the whole preheating system is mounted. Photograph by courtesy of British Steel Corporation.

APPLICATIONS

The reGen Regenerative Burner is suitable for application on a wide spectrum of batch and continuous direct fired furnaces in the steel, non ferrous, ceramics, heavy clay and glass industries.

As with all energy recovery systems the potential saving becomes higher as the process temperature increases, but the reGen offers such high efficiencies that its use may be justified at lower temperatures where other devices such as recuperators cannot match its performance.

Forge furnaces, continuous steel reheaters, heat treatment furnaces, non ferrous metal melting furnaces, shuttle kilns, glass daytanks are typical applications to which the reGen is well suited.

Listed below are some of the reGen installations:

FORGING

Applied to a 1000 lb/hr slot forge furnace a reGen system has produced specific fuel consumption of 450 BTU/lb for leaf spring eye forming at 1700°F and 701 BTU/lb heating forging stock to 2340°F - a minimum 60% saving over conventional slot forges.

A reGen system on a 100 ton box forge furnace is providing 2200°F air preheat at 2300°F furnace temperature.

HEAT TREATING

On coil annealing furnaces operating at 1700°F maximum, 37% fuel savings have been achieved.

STEEL

A 50 Ton/hr stainless strip soften and descale line with 24 reGen burners for a total of 42 million BTU/hr has produced record tonnage with a 40% fuel saving.

Specific fuel consumption has reduced in excess of 60% on a 30 Ton/hr, 4 zone roller hearth plate furnace. It is operating at 2000°F with 24 reGen burners for a total of 12 million BTU/hr.

A 150 Tonne AOD vessel preheater/maintainer fitted with a 6 million BTU/hr reGen system is holding the vessel at 1800°F with 3 million BTU/hr, where the original air/gas/oxygen burner consumed 12 million BTU/hr.

GLASS

reGen is giving preheated air at 2280°F to a 2550°F soda lime glass tank and producing final waste gas temperatures of 350°F. Blockage of the regenerator by condensed volatiles is quickly and easily relieved by simple cleaning without shutting down the system.

SYSTEM CONFIGURATIONS

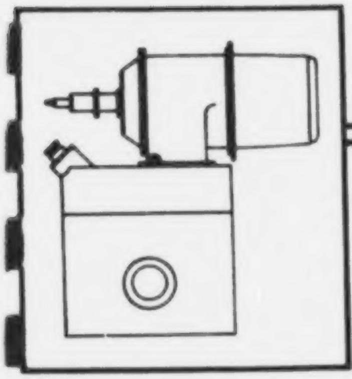
Four sizes of unit are currently available - 1, 2, 3 and 6 million BTU/hour input when operating at 2000°F plus with air pressures under 27"wc. Other sizes are being built as applications demand.

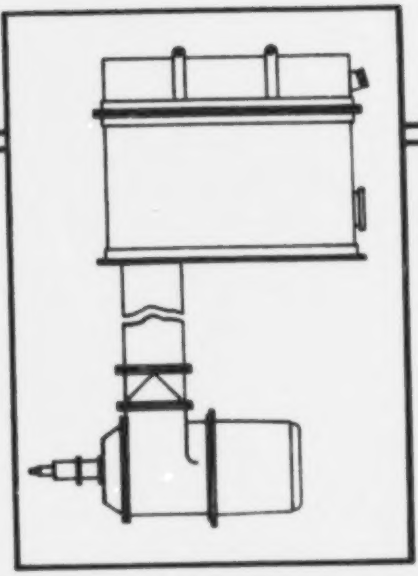
The standard configuration is a cylindrical regenerator mounted below its burner with upward combustion air flow. For installations where space is limited the regenerators can be made rectangular and their aspect ratio can be altered to reduce height or cope with special width requirements.

In the inverted configuration the regenerators can be mounted above their burners. The regenerators are rectangular and may be made as a pair contained within a common steel case when the two burners of a pair are adjacent.

reGen may be incorporated directly into a furnace structure. In this case, low pressure drop regenerators are normally used, with the advantage that low pressure air driven ejectors may be used for exhaust draft provision instead of fans.

The incorporated configuration is purpose designed for each job - for example, units have been built directly into the legs of slot forge furnaces and, for an aluminum melter, could be built as units with roof sections incorporating special low pressure reGen burners.

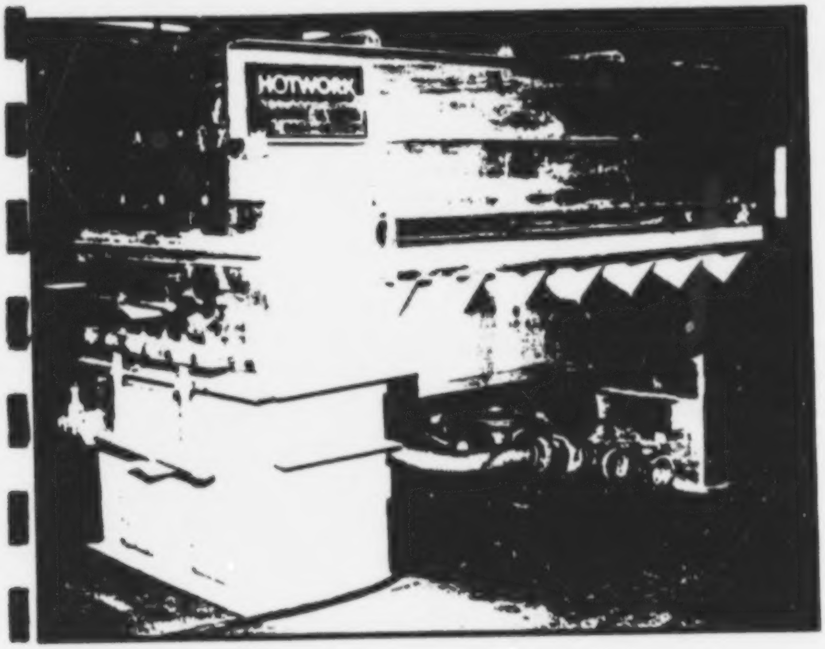




Above: Standard reGen

Right: Inverted reGen

Below: reGen System incorporated into a 1,000 lb/hr slot forge furnace.



ABOUT reGen

The reGen Regenerative Burner is the product of a joint technical and commercial development program between Hotwork Development Ltd., Dewsbury, England and British Gas.

Producers of the highly successful HRB recuperative burner since the early '70's, Hotwork commenced laboratory trials of reGen production prototypes in September 1982, installing the first field trial, on a glass melting furnace operating to 2600°F, at the start of 1983.

reGen Systems Inc. of Lexington, Kentucky was formed in December 1983 by John N. Newby, formerly Managing Director of Hotwork Development Ltd., as the exclusive licensee for the reGen Regenerative Burner for North America.

reGen Systems Inc.
606 North Broadway
Lexington, KY 40508 U.S.A.
(606) 252-2272 Telex: 755829

APPENDIX D

GENERAL NOTES ON METHOD FOR COST ESTIMATES AND ANALYSIS FOR CENTRAL RECUPERATOR OPTION

CONTENTS: PAGES

- APPROACH TO ESTIMATING CAPITAL COSTS D1
- BASIS FOR PIPING/DUCTING COSTS D2
- SUMMARY OF COSTS FOR CENTRAL RECUPERATOR OPTION D3
- CHECK REQUIREMENTS FOR NEW FANS, BLOWERS D4 - D7
- COST FOR RECUPERATOR D8
- PIPING/DUCTING REQUIREMENTS D9 - D11
- FUEL SAVINGS D12 - D13
- FAN POWER SAVINGS D14 - D15

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

SHEET NO. D1 OF

DESCRIPTION	PROJ NO	MADE BY	CHECKED BY
EMR ENERSOLVE – STANTON PIPES	9036	DATE APR./85	DATE

APPROACH TO ESTIMATING CAPITAL COSTS

① Estimate material costs including structural, electrical, controls

② Estimate costs for labour and any equipment required for installation of above.

③ TOTAL DIRECT COSTS = Sum of above

④ Estimate INDIRECT COSTS + CONTINGENCIES as follows:

Detailed Engineering, Procurement, Construction Management } = 25 % OF TOTAL DIRECT COSTS

Freight, Startup, Temporary facilities, insurance } = 10 % of T.D.C.

Contingencies = 15 % of T.D.C.

TOTAL INDIRECTS + CONTINGENCIES = 50 % of T.D.C.

EXCLUSIONS : – TAXES (ASSUME NONE FOR ENERGY CONSERVATION PROJECT)

– INTEREST CHARGES FOR ANY DEBT FINANCING

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D2 OF

DESCRIPTION EMR. ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE APR/85	CHECKED BY DATE

BASIS FOR, PIPING/DUCTING COSTS

MILD STEEL PIPING : USE #4/LB TOTAL INSTALLED COST INCLUDING INSTALLATION, SUPPORTS, FLANGES, FITTINGS, BENDS.

INSULATION : BASED ON QUOTE FROM DEWAR (PR. 2407), FOR 3" INSULATION + CLADDING, TOTAL COST INCLUDING INSTALLATION, WASTAGE, TRANSITIONS ≃ #12/ft²

CASTABLE REFRACTORY (INSULATING) : BASED ON TELEPHONE CONVERSATION WITH CRL - MONTREAL (514-861-1831), COST FOR INSULATING DUROLITE 22 CASTABLE REFRACTORY → #27.30/25 kg, 50 LB/FT³ CAST

WITH 75% ADDITIONAL COST FOR LABOUR

$$\frac{\text{COST}}{\text{INSTALLED ft}^3} = \frac{\#27.30 \times 1.75}{25\ \text{kg}} \times \frac{1\ \text{kg}}{2.2\ \text{lb}} \times \frac{50\ \text{LB}}{\text{ft}^3}$$

$$= \#43.43/\text{ft}^3$$

USE #60/ft³ INCLUDING ALLOWANCE FOR WASTAGE

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D3 OF

DESCRIPTION	PROJ. NO.	MADE BY	CHECKED BY
EMR ENERSOLVE – STANTON PIPES	9036	SK DATE	DATE

SUMMARY OF COSTS FOR CENTRAL RECUPERATOR OPTION

HX INCLUDING LABOUR, SUPPORTS	#28,000
COMBUSTION AIR FAN	#7,500
EXHAUST GAS FAN	#50,000
EXHAUST GAS DUCTING MILD STEEL SHELL : (2656+2650) 4 = #21,200 INSULATING REFRACTORY : 170 × 60 = #10,200	#31,400
COMBUSTION AIR PIPING MILD STEEL SHELL : (337+820) 4 = #4,600 INSULATION : 630 × 12 = #7,600	#12,200
COMBUSTION CONTROLS (RATIO CONTROLLER, VALVES, REGULATORS) ↳ BASED ON TELEPHONE CONVERSATION WITH NORTH AMERICAN MFG. CO.	#55,000
T.D.C.	#184,100
INDIRECT COSTS (AT 50 %) + CONTINGENCIES	#92,000
TOTAL CAPITAL COST	#276,100

ANNUAL OPERATING SAVINGS:

FUEL	#137,700
MAINTENANCE (AT 3 % T.D.C.)	−5,500
FAN POWER	700
NET ANNUAL OPERATING SAVINGS:	#132,900

$$\text{PAYBACK} \simeq \frac{276,100}{132,900} = 2\cdot1 \text{ YEARS}$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D4 OF
DESCRIPTION EMP ENERCOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY CK DATE APR/85	CHECKED BY DATE

CAPACITY OF PRESENT BLOWERS

NEW BLOWER - BASED ON LETTER FROM CANEFCO DATED MAR.27/80 : 2990 CFM @ 16 osi, 20 HP

OLD BLOWER - BASED ON LETTER FROM BLOOM ENGS. DATED MAR. 18/85 : 2175 CFM @ 10 osi.

RATED BURNER AIR PRESSURES : 7" - 28" W.C.
or 4.1 - 16.4 osi.

IF AIR IS PREHEATED TO 600 °F, DENSITY WILL BE
$= \frac{520}{600+460} \cong 50\%$ OF BEFORE.

THE REQUIRED MASS FLOW OF AIR WILL BE ≃ 1/2 OF CURRENT DUE TO REDUCED FUEL REQUIREMENT DUE TO WASTE HEAT RECOVERY. ∴ FOR SAME SYSTEM RESISTANCE Δp WILL BE HALVED. HOWEVER THERE WILL BE AN ADDITIONAL LOSS ACROSS RECUPERATOR.

THE FANS MAY ENTER AN UNSTABLE OPERATING REGIME WITH LOWER DENSITY & LOWER MASS FLOW.

THE PRESSURE LOSSES CANNOT BE CALCULATED WITHOUT KNOWLEDGE OF ALL PIPING LAYOUT - UNAVAILABLE AT PRESENT.

FOR PRESENT ANALYSIS, ASSUME NEW COMBUSTION AIR FAN WILL BE REQUIRED.

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9033	MADE BY DATE APR/85	SHEET NO. D5 OF CHECKED BY DATE

OPTIONS FOR HOT GAS HANDLING

COMPARE COSTS FOR FOLLOWING 2 OPTIONS FOR HANDLING ABOUT 3500 SCFM FLUE GAS AT ≃ 1000 °F

OPTION ① : HOT GAS FAN CAPABLE OF HANDLING FLUE GASES AT 1000 °F

BASED ON QUOTE FROM NOVENCO FOR PROJ. 4302, ALLOW ≃ $50,000 INSTALLED

OPTION ② : STANDARD FAN WITH FLUE GASES AIR COOLED DOWN TO ≃ 400 °F

LET x = SCFM AMBIENT AIR AT 80 °F REQUIRED FOR COOLING

∴ ENERGY BALANCE:

$$3500\,(1000-80) = (3500+x)\,(400-80)$$

$$x \cong 6900 \text{ SCFM}$$

∴ TOTAL FLOW THROUGH FAN

$$= (6900+3500)\left(\frac{460+400}{520}\right)$$

$$= 17{,}200 \text{ ACFM} \rightarrow 2\tfrac{1}{2}' \text{ DUCT DIA.}$$

BASED ON PRICE QUOTES FOR PR. 6979 (INQUIRY # 009), ALLOW ≃ $15,000 FOR FAN, MOTOR

ALLOW $30,000 TOTAL INCLUDING LABOUR, SUPPORT, ELECTRICS

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO. D6 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES		PROJ NO 9036	MADE BY CK DATE APR/85	CHECKED BY DATE

OPTION ② WILL HAVE THE FOLLOWING ADDITIONAL REQUIREMENTS:

- LARGER DUCTS FOR CARRYING AIR
- LONGER DUCT BEFORE THE FAN TO ALLOW FOR MIXING OF FLUE GASES & AIR.
- HIGHER ANNUAL POWER COSTS
- LARGER FAN SIZE

USE OPTION ① FOR PRELIMINARY COSTING OF OPT. [illegible] AS THE ADDITIONAL COSTS WILL NOT BE SIGNIFICANT BUT OPTION ① DOES OFFER A SIMPLER LAYOUT.

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D7 OF

DESCRIPTION ENG. ENERSOLVE - STANTON PIPES	PROJ NO 9036	MADE BY DATE	CHECKED B DATE

NEW FANS FOR WASTE HEAT RECOVERY OPTION

a) COMBUSTION AIR FAN:

FLOW → ALLOW 3000 SCFM
PRESSURE GAIN → CANNOT BE SPECIFIED WITHOUT
CALCULATIONS OF LOSSES IN
PIPING SYSTEM. FOR PRESENT
ASSUME ≃ 25 osi.

QUOTE FROM CANEFCO FOR A 3000 SCFM, 16 osi
BLOWER. ≃ #4,200 FAN + MOTOR. (MARCH 1980)

ESTIMATED COST FOR THE REQUIRED FAN + MOTOR
≃ #5,000 (INCLUDING INFLATION FACTOR)

ASSUMING THAT MOST OF EXISTING ELECTRICS CAN BE
RE-USED, ALLOW TOTAL INSTALLED COST OF #7500

b) EXHAUST GAS FAN:
FLOW - ALLOW 3500 SCFM @ ≃ 4" W.C. (EST.); ≃1000
BASED ON A QUOTE FROM NOVENCO FOR PROJ. 43
ALLOW ≃ #50,000 INSTALLED

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO. D8 OF
DESCRIPTION EMP ENERSOLVE – STANTON PIPES		PROJ. NO. 9036	MADE BY SK DATE APR./85	CHECKED BY DATE

CENTRAL RECUPERATOR FOR EXHAUST GASES

TELEPHONE CONVERSATION WITH T. KILMER, INDUSCO (231-9377):
RECOMMENDS MODEL SP50-5000, 304 S/S
FLOW ≃ 3500 SCFM EACH WAY
EXHAUST GASES: 1300°F → 642°F } 50.6 %
COMBUSTION AIR: 0°F → 658°F } EFFECTIVENESS
OVERALL CASING DIMENSIONS (EXCL. FLANGES):
36" × 36" × 50" LENGTH
EXHAUST GAS IS SINGLE PASS ALONG LENGTH,
AIR IS DOUBLE PASS
COST ≃ $17,500 INCL. CASING

ALLOW 60 % ADDITIONAL FOR TRANSITIONS, SUPPORTS,
LABOUR, FRAME, INSULATION
= $10,500

∴ TOTAL CAPITAL COST FOR HEAT EXCHANGER = $28,000

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO D9 O
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE APR/85	CHECKED DATE

PIPING REQUIREMENTS FOR WASTE HEAT RECOVERY OPTION

a) EXHAUST DUCTING -

SIZE OF FLUE GAS EXHAUST:

NOMINAL FLOWRATE OF FLUE GAS = 3060 SCFM @ 1300°F
= 10,400 ACFM

USE 13,000 ACFM @ 4000 FPM

$$AREA = \frac{13,000}{4,000} = 3.25\ ft^2 \Rightarrow DIA = 2'$$

or 1.8' × 1.8' squar

or 1' × 3.25'

APPROXIMATE LENGTH TO HX ≃ 40'; $WT. = 40 \times (3.25+1)\,2 \times \frac{3/16}{12} \times 500 = 2652$

CHECK THICKNESS OF INSULATION REQUIRED FOR AN OUTER SKIN TEMPERATURE OF ABOUT 200°F

$$\frac{HEAT\ LOSS}{FT^2} \doteq \varepsilon\sigma\left(T_G^4 - T_i^4\right) = \frac{k}{\Delta x}\left(T_i - T_o\right) = h_c\left(T_o - 540\right)$$

$$(0.9)(.1714)10^{-8}\left(1760^4 - T_i^4\right) = \frac{1.5}{\Delta x}\left(T_i - 660\right)$$

$$= 5\,(660 - 540)$$

$$(.154)10^{-8}\left(9.595\times10^{12} - T_i^4\right) = 600 = \frac{1.5}{\Delta x}\left(T_i - 660\right)$$

$$T_i = 1740°F$$

$$\Rightarrow \Delta x = \frac{1.5}{600}\left(1740 - 660\right)$$

$$\simeq 2.5'' \Rightarrow ALLOW\ 3''$$

FLUE GAS DUCT AFTER HX: ALLOW ≃ 3500 SCFM @ 1000°F
≡ 9,800 ACFM

$$AREA = \frac{9,800}{4000} \cong 2.5\ ft^2 \rightarrow 1.8'\ DIA.$$

APPROXIMATE LENGTH FROM HX TO DISCHARGE ABOVE EXIT DOOR OF FURNACE ≑ 60' ; $WEIGHT = (1.8\pi)\,60 \times \frac{3/16}{12} \times 500$

$= 2650$ lb.

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D10 OF

DESCRIPTION EMR ENER.SOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY DATE APR/85	CHECKED BY DATE

REFRACTORY REQUIREMENTS:

ESTIMATED VOLUME

$$\simeq \left\{2(1+3.25)\,40 + (1.8\pi)\,60\right\}\frac{3}{12} = 170\ ft^3$$

b) COMBUSTION AIR PIPING

SIZE BASED ON 2500 SCFM @ 4000 FPM

BEFORE HX : $AREA = \dfrac{2500}{4000} = 0.63\ ft^2$

$\Rightarrow D \cong 11''$, ALLOW 15'

WEIGHT = 337 lb

AFTER HX : AIR TEMP. $\simeq 600\ ^\circ F$

$AREA = \dfrac{2500 \times 1060/520}{4000} \equiv 1.3\ ft^2$

$\Rightarrow D \cong 16''$

ALLOW 25' TO CONNECTION WITH EXISTING PIPING.

$WEIGHT \simeq (25)\left(\frac{16}{12}\right)\pi\left(\frac{3/16}{12}\right)500 = 820\ lb$

INSULATION REQUIREMENTS:

ESTIMATE AT 400' OF 6" EQUIVALENT ϕ,

$AREA = \pi\,\frac{6}{12})\,400 = 630\ ft^2$

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Consulting Engineers

CALCULATION SHEET

SHEET D11

DESCRIPTION EMR ENERSOLVE - STANTON PIPES

PROJ NO 9036

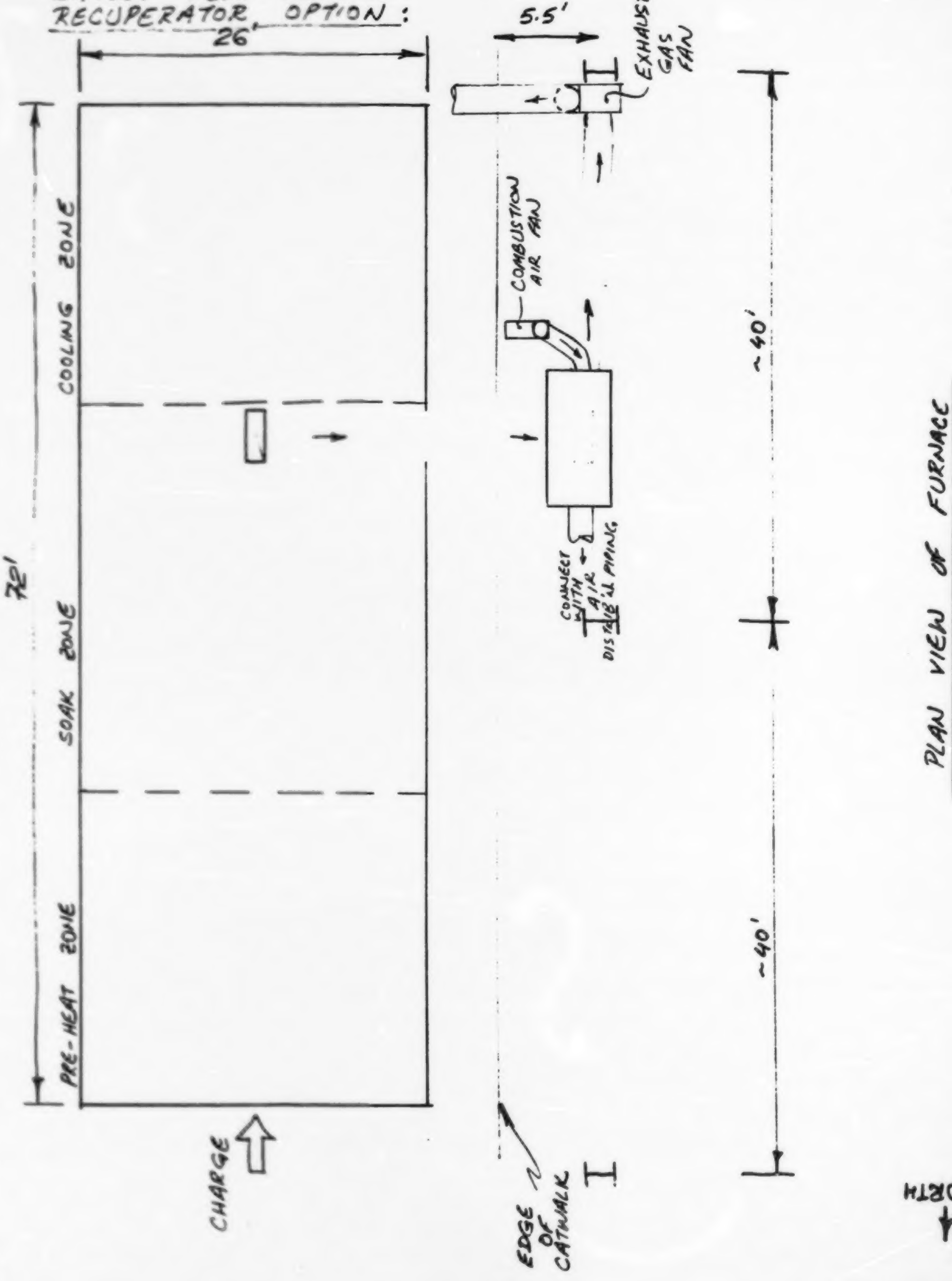
MADE BY SK

DATE

CHECK

DATE

LAYOUT FOR CENTRAL RECUPERATOR OPTION:



26'
5.5'
EXHAUST GAS FAN
72'
COOLING ZONE
SOAK ZONE
PRE-HEAT ZONE
COMBUSTION AIR FAN
CONNECT WITH AIR DISTRIB'N PIPING
~40'
~40'
CHARGE
EDGE OF CATWALK
PLAN VIEW OF FURNACE
ORTH

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D12 OF......

DESCRIPTION	PROJ. NO.	MADE BY	CHECKED BY
EMR ENERSOLVE — STANTON PIPES	9036	SK APR/85 DATE	DATE

FUEL CONSUMPTION WITH WASTE HEAT RECOVERY

OVERALL ENERGY BALANCE ON FURNACE:

ENERGY IN FUEL + SENSIBLE ENERGY OF PREHEATED COMBUSTION AIR

= ENERGY IN FLUE GASES (1)
+ RADIATION LOSSES THROUGH OPENINGS (2)
+ SHELL LOSSES (3)
+ NET ENERGY TO PIPES (4)
+ CONVEYOR LOSSES (5)
+ COOLING WATER LOSSES (6)

ASSUME THAT WITH WASTE HEAT RECOVERY:

- LOSSES 3-6 WILL REMAIN UNCHANGED
- RADIATION LOSSES THROUGH OPENINGS WILL BE ABOUT 75% OF BEFORE DUE TO IMPROVED SHIELDS AT CHARGE DOOR. (CAPITAL COSTS FOR THIS TO BE ALLOWED FOR IN CONTINGENCIES)
- INFILTRATION AIR ≐ 840 SCFM (THE FIGURE ESTIMATED IN APPENDIX B)
- CHANGES ARE ALSO MADE TO BURNER CONTROLS SO THAT AIR : FUEL RATIO IMPROVED TO 12:1

LET x = SCFH OF NATURAL GAS

∴ ENERGY IN FUEL BASED ON L.H.V. = $900\,x \ \frac{BTU}{h}$

COMBUSTION AIR REQUIRED = $12x$ SCFH

FLUE GAS VOLUME = $(13x) + (840)\,60$ SCFH

COMBUSTION AIR IS PREHEATED TO 600 °F WITH EXISTING BURNERS

FLUE GAS TEMP. EXITING FURNACE ≃ 1300 °F

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. D13 OF
DESCRIPTION EMR. ENERSOLVE – STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE APR/85
		CHECKED BY DATE

∴ ENERGY BALANCE BECOMES :

$$900x + (12x)\left(.019\,\frac{BTU}{SCF\text{-}°F}\right)(600-60)°F$$

$$= (13x + 50{,}400)(.019)(1300-60) +$$

$$+ (18.5)10^6 \left\{ .19 \times \frac{3}{4} + .10 + .05 + .04 \right\}$$

$$900x + 123x = 306x + (1.19)10^6 + (6.15)10^6$$
$$717x = (7.34)10^6$$

$$\underline{x = 10{,}240 \text{ SCFH}}$$

$$12x = 2050 \text{ SCFM}$$

COMPARED WITH
20,500 SCFH AT
PRESENT
ie. 50% REDUCTION

FLUE GAS VOLUME = $(13)\,10{,}240 + 50{,}400 = 183{,}520$ SCFH
= 3060 SCFM

SIZE SYSTEM BASED ON
3500 SCFM

ANNUAL SAVINGS = $(20{,}500 - 10{,}240)\,\frac{12h}{day} \times 5\,\frac{day}{wk} \times 52 \times \frac{4.3}{10^3}$

$= \underline{\$137{,}700}$

NOTE : THE FLUE GAS TEMPERATURE AT THE END OF SOAK ZONE WHERE EXHAUST IS LOCATED WILL BE ABOUT 1800°F, NOT 1300°F. SINCE THE AIR PREHEAT TEMPERATURE IS RESTRICTED TO 600°F, THE MAJOR IMPACT WILL BE ON RECUPERATOR SIZE & COST. CONSERVATIVELY USE HX COST BASED ON 1300°F.

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. D14 OF
DESCRIPTION EMR ENERSOLVE -STANTON PIPES	PROJ. NO. 9036	MADE BY DATE	CHECKED BY DATE

INCREMENTAL FAN POWER COSTS WITH CENTRAL RECUPERATOR

a) COMBUSTION AIR FAN

$$HP = \frac{\frac{FT^3}{S} \times \frac{LBF}{FT^2}}{\eta \times 550 \frac{FT\text{-}LBF}{HP\text{-}S}}$$

WITH WASTE HEAT RECOVERY & IMPROVED CONTROLS,

$$\text{NEW FLOW(CFS)} = \underset{\text{FLOW}}{\text{ORIGINAL}} \times \frac{2050}{5200} \times \frac{600+460}{520}$$

$$= 0.8\, V_0$$

NEW PRESSURE DROP ASSUMING SYSTEM RESISTANCE INCREASES 15% DUE TO RECUPERATOR

$$= \text{ORIGINAL } \Delta p \times \frac{\rho_2}{\rho_1} \times \left(\frac{VEL_2}{VEL_1}\right)^2 \times 1.15$$

$$= \Delta p)_0 \times \frac{520}{1060} \times (0.8)^2 \times 1.15$$

$$= 0.36 (\Delta p)_0$$

CURRENT TOTAL HP = 19.5 + 10 = 29.5 HP

NEW HP REQMTS. = (0.8 × 0.36) 29.5 = 8.5 HP

REDUCTION = 29.5 − 8.5 ≃ 21 HP

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET		SHEET NO. D15 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE	CHECKED BY DATE

b) EXHAUST GAS FAN

ALLOW 3500 SCFM @ 4" W.C., 1000 °F
(164 CFS)

$$HP = \frac{164\ \frac{ft^3}{s} \times (4 \times 5.2)\frac{LBF}{FT^2}}{0.6\ \text{efficiency} \times 550} \cong \underline{11\ HP}$$

INCREASE

c) TOTAL

NET REDUCTION ≈ 21 - 11 = 10 HP

$$\text{ANNUAL SAVINGS} = (10\ HP)\left(\frac{.746\ kW}{HP}\right)\left(\frac{12 \times 5 \times 52\ h}{YR}\right)\left(\frac{\$.03}{kW\text{-}h}\right)$$

$$\cong \underline{\$700/YR.}$$

APPENDIX E

ANALYSIS FOR SELF-RECUPERATIVE BURNERS OPTION

CONTENTS:

	Pages
• SUMMARY OF COSTS	E1
• DETAILS & BASIS FOR COSTS	E2-E4

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

SHEET NO. E1 OF

DESCRIPTION EMR. ENERSOLVE - STANTON PIPES

PROJ. NO. 9036

MADE BY SL

DATE

CHECKED BY

DATE

SUMMARY OF COSTS FOR RECUPERATIVE BURNERS

RECUPERATIVE BURNERS c/w CONTROLS	#310,000
COMBUSTION AIR FAN	#7,500
EDUCTOR AIR FAN	#50,000
EDUCTOR AIR PIPING	#15,000
T. D. C.	#382,500
INDIRECT COSTS (AT 50%) + CONTINGENCIES	#191,300
TOTAL CAPITAL COSTS	# 573,800

ANNUAL OPERATING SAVINGS:

FUEL	#137,700
FAN POWER	0
MAINTENANCE (3% of T.D.C.)	- 8,500
NET ANNUAL SAVINGS	#129,200

PAYBACK $\simeq \frac{573,800}{129,200}$ = 4.4 YEARS

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

SHEET NO. E2 OF

DESCRIPTION: EMR ENERSOLVE - STANTON PIPES

PROJ. NO. 9036

MADE BY

DATE

CHECKED BY

DATE

TELEPHONE CONVERSATION WITH R. CHAPMAN, NORTH AMERICAN MFG. CO., APR. 25/85

Re : Waste Heat Recovery on Annealing furnace using Self-Recuperative or Regenerative Burners.

a) SELF-RECUPERATIVE BURNERS

- MATERIAL COST FOR SYSTEM ≃ $200,000 (PRELIMINARY ONLY)
  IT INCLUDES - 20 BURNERS FOR FIRST 2 ZONES.
  (INSTALLED BURNER FIRING CAPACITY ≃ 50% OF PRESENT)
  - TEMPERATURE COMPENSATED CONTROLLERS
  - VALVES FOR AIR LINES
  - COST FOR CONTROLS SYSTEM ONLY ≃ $45,000
- EFFICIENCY IS LOWER, THAN FOR REGENERATIVE BURNERS OF SAME SIZE
- ADDITIONAL COST FOR EDUCTOR ≃ $2000 PER BURNER

b) REGENERATIVE BURNERS (TWIN BED TYPE)

- MATERIAL COST FOR SYSTEM ≃ $169,000 FOR FIRST 2 ZONES
  (COST FOR BURNERS ONLY ≃ $123,000)
- INSTALLED CAPACITY OF BURNERS ≃ 50% IN THESE 2 ZONES.
- CONTROLS INCLUDE REGULATORS & AIR VALVES
- TYPICALLY BURNERS OPERATE AT 10% XS AIR
- FOR FLUE GAS TEMP ≃ 1600°F, EXHAUST TEMP. FROM BED ≃ 400°F; HX EFFECTIVENESS UPTO 85%
- BURNER BLOCK SIZE ≃ 10"-12"
- PRESSURE DROPS : 12 OSIG. IN BURNER FOR AIR, 5" W.C. IN BED.
- EXHAUST FAN TYPICALLY USED FOR HANDLING FLUE GASES
- TYPICALLY ALLOW 25-30% FOR ALL AIR, FLUE PIPING

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. E3 OF

DESCRIPTION	PROJ. NO.	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON PIPES	9036	SK	
		DATE	DATE

BASIS FOR COSTS USED FOR SELF-RECUPERATIVE BURNERS OPTION

CAPITAL COSTS:

a) COMBUSTION AIR FAN - AS FOR CENTRAL RECUPERATOR OPTION
= #7,500

b) EDUCTOR FAN - ALLOW 20 × #2500
= #50,000 INSTALLED

c) COMBUSTION AIR PIPING - ASSUME NO NEW PIPING NEEDED

d) EDUCTOR PIPING - ALLOW #15,000

e) COMBUSTION CONTROLS -
BASED ON TELEPHONE QUOTE ≃ #45,000 MATLS. ONLY

ALLOW #65,000 INSTALLED

f) BURNERS - BASED ON TELEPHONE QUOTE
≃ $ 155,000 MATLS. ONLY

ALLOW 1.5 × #155,000 ≃ #235,000 INSTALLE

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. E4 OF

DESCRIPTION	PROJ. NO.	MADE BY	CHECKED BY
EMR ENERSOLVE - STANTON PIPES	9036	SK DATE	DATE

OPERATING COSTS :

a) FUEL - RECUPERATIVE BURNERS PROVIDE AIR PREHEAT OF 600 °F.

∴ USE $137,700 AS FOR CENTRAL RECUPERATOR OPTION

b) FAN POWER :

CENTRAL RECUPERATOR OPTION HAD SAVINGS OF ≃ $700. HERE WITH LOWER EFFICIENCY OF EDUCTOR, HIGHER Δp OF BURNERS

ASSUME NO SAVINGS

c) MAINTENANCE:

TAKE 3% OF TOTAL DIRECT COSTS

- ALLOWANCE OF $3000 FOR MAINTENANCE ON EXISTING BURNERS

$= (.03)\ 382{,}500 - 2{,}500 \cong \$8{,}500$

APPENDIX F

ANALYSIS FOR REGENERATIVE BURNERS OPTION

PAGES

CONTENTS:

- SUMMARY & BASIS of COSTS FOR "NORTH AMERICAN" REGENERATIVE BURNERS F1 - F3
- COSTS FOR "REGEN" REGENERATIVE BURNERS F4

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET	SHEET NO. F1 OF
DESCRIPTION EMR ENERSAVE - STANTON PIPES	PROJ. NO. 9036	MADE BY SK DATE
		CHECKED BY DATE

SUMMARY OF COSTS FOR REGENERATIVE BURNERS - NO. AMERICAN

COMBUSTION AIR FAN	#7,500
EXHAUST GAS FAN	#25,000
EXHAUST GAS PIPING	#25,000
COMBUSTION CONTROLS	#65,000
BURNERS	#185,000
TOTAL DIRECT COSTS	#307,500
INDIRECT COSTS + CONTINGENCIES (AT 50%)	153,800
TOTAL CAPITAL COSTS	#461,300

ANNUAL OPERATING SAVINGS :

FUEL	162,500
FAN POWER COSTS	0
MAINTENANCE	-6,200
NET ANNUAL SAVINGS	#156,300

$$\text{PAYBACK} = \frac{\#461,300}{156,300} = 3.0 \text{ YEARS}$$

HA - E5/73

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO. F2 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES		PROJ. NO. 9036	MADE BY SK DATE	CHECKED BY DATE

BASIS FOR COSTS USED FOR NORTH AMERICAN REGENERATIVE BURNERS OPTION

CAPITAL COSTS:

a) COMBUSTION AIR FAN - #7,500 AS BEFORE

b) EXHAUST GAS FAN - ALLOW #25,000 INSTALLED
FOR A STANDARD FAN
OPERATING AT ≃ 400 °F

c) COMBUSTION AIR PIPING - ASSUME NO NEW PIPING
NEEDED

d) COMBUSTION CONTROLS - ALLOW #65,000 INSTALLED
AS FOR SELF RECUPERATIVE
BURNERS

e) BURNERS - BASED ON TELEPHONE QUOTE
≃ #123,000 MATLS. ONLY

ALLOW 1·5 × #123,000 ≃ #185,000
INSTALLED

f) EXHAUST GAS PIPING
- BASED ON TELEPHONE CONVERSATION WITH MFR.
ALLOW (.15 × 169,000) ≃ #25,000 INSTALLED

HATCH ASSOCIATES
Consulting Engineers

CALCULATION SHEET

SHEET NO. F3 OF			
DESCRIPTION EMR ENERSOLVE	PROJ. NO. 9036	MADE BY SK DATE	CHECKED BY DATE

OPERATING COSTS:

a) FUEL : EFFICIENCY UPTO 85% FOR REGENERATOR. ASSUME THAT WITH BETTER REGULATION OF COMBUSTION AIR, ABOUT 95% OF PRESENT ENERGY IN FLUE GASES WILL BE SAVED.

$$\text{ie. } (18.5)10^6 \frac{BTU}{h} \times (0.62) \times 0.95$$

$$= (10.9)10^6 \frac{BTU}{h} \quad (\text{BASED ON LHV})$$

$$= \frac{(10.9)10^6}{900} \frac{scf}{h} \times 12 \times 5 \times 52 \times \frac{\$4.3}{10^3\ scf}$$

$$= \underline{\$162{,}500}$$

b) FAN POWER:
ASSUME NO SAVINGS

c) MAINTENANCE:
TAKE 3% OF TOTAL DIRECT COSTS
- ALLOWANCE OF $3000 FOR MAINTENANCE ON EXISTING BURNERS

$$= (0.03)(307{,}500) - 3000$$

$$\cong \underline{\$6{,}200}$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO. F4 OF
DESCRIPTION EMR, ENERSOLVE – STANTON PIPES		PROJ. NO. 9036	MADE BY DATE	CHECKED BY DATE

BASIS FOR COSTS USED FOR "REGEN" REGENERATIVE BURNERS OPTION

T/C JOHN NEWBY, REGEN SYSTEMS, APR. 26/85:

TOTAL COST FOR SYSTEM (INCLUDING BURNERS, CONTROLS, LABOUR, BLOWERS, EDUCTOR, PIPING)

ALLOW ≃ U$ 240,000

∴ ALLOW TOTAL DIRECT COSTS OF
1·35 × $ 240,000
= $325,000

TOTAL INCLUDING INDIRECTS + CONTINGENCIES : $487,500

NET OPERATING SAVINGS (ANNUAL)

↳ ALLOW SAME AS FOR NORTH AMERICAN REGENERATIVE BURNERS ≃ $ 156,300

PAYBACK ≃ $\frac{487,500}{156,300}$ = 3·1 YEARS

APPENDIX G

ANALYSIS FOR IMPROVED FURNACE CONTROLS OPTION

HATCH ASSOCIATES
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CALCULATION SHEET

DESCRIPTION EMR ENERSOLVE — STANTON PIPES	PROJ NO. 9036	MADE BY DATE APR/85	CHECKED BY DATE	SHEET NO. G1 OF

FUEL SAVINGS WITH IMPROVED FURNACE CONTROLS OPTION

CALCULATE NATURAL GAS FIRING RATE BASED ON 12:1 AIR-FUEL RATIO AND NO WASTE-HEAT RECOVERY EQUATION FROM PAGE D13 :

$$900\,x = 306\,x + (7.34)\,10^6$$

$$x = 12,360 \text{ SCFH}$$

REDUCTION OVER PRESENT = 20,500 - 12,400
= 8100 SCFH

ANNUAL SAVINGS

$$= 8100\ \frac{SCF}{H} \times \frac{12\ H}{DAY} \times 5\ \frac{DAYS}{WK} \times \frac{52\ WKS}{YR} \times \frac{\$4.3}{10^3 BTU}$$

= $108,700 IN FUEL

ADDITIONAL SAVINGS BY A RECUPERATOR
= 12,400 - 10,240 = 2160 SCFH

$$\text{ANNUAL BASIS} : 2160 \times 12 \times 5 \times 52 \times \frac{4.3}{10^3}$$

= $29,000

CAPITAL COSTS — ALLOW COSTS FOR CONTROLS, EXHAUST GAS FAN, EXHAUST GAS DUCTING AS FOR CENTRAL RECUPERATOR OPTION

FAN POWER SAVINGS — ALLOW SAME AS FOR CENTRAL RECUPERATOR OPTION

MAINTENANCE COSTS = 3% × T.D.C (INCREASE

APPENDIX H

ANALYSIS FOR IMPROVED RADIATION SHIELDS OPTION

CONTENTS:

	PAGES
• CALCULATION OF HEAT LOSSES WITH IMPROVED RADIATION SHIELDS	H1 - H3
• CALCULATION OF COSTS FOR INSULATION	H4

HATCH ASSOCIATES Consulting Engineers	**CALCULATION SHEET**		SHEET H1
DESCRIPTION EMP, ENERSOLVE - STANTON PIPES	PROJ. NO 9036	MADE BY SK DATE MAR/85	CHECK DATE

CALCULATE REDUCTION IN HEAT LOSSES AT CHARGE EN

WITH INSULATION (FIBERFRAX CLOTH), THERE WILL BE A
LARGE ΔT ACROSS THICKNESS.

$$\Delta T = T_{CURTAIN,\,HOT} - T_{CURTAIN,\,COLD}$$

$$k_{INSUL} \simeq 0.6 \text{ BTU-in/h-ft}^2\text{-°F} \ @\ T_{mean} = 800°F$$

$\varepsilon_{\substack{INSULATING\\CURTAIN}} \Rightarrow$ NOT KNOWN, LIKELY IN RANGE OF 0.5-0

DO CALCS FOR $\varepsilon = 0.5$ AND 0.8

HEAT TRANSFER EQTNS:

$$\frac{\sigma\,(T_{FCE}^4 - T_{CH}^4)}{\frac{1}{\varepsilon_{FCE}} + \frac{1}{\varepsilon_c} - 1} = \frac{\sigma\,(T_{CC}^4 - 5.45^4)}{\frac{1}{\varepsilon_c} + \frac{1}{\varepsilon_{AMB}} - 1} + h\,(100\,T_{CC} - 545)$$

$$= \underbrace{k\left(\frac{T_{CH} - T_{CC}}{\Delta x}\right)}_{\text{CONDUCTION ACROSS INSULATION}}$$

HAVE 2 EQNS. & 2 UNKNOWNS

USE $\Delta x \approx 1/4''$

a) FOR $\varepsilon_c = 0.5$

$$\therefore \frac{(.1714)(19.6^4 - T_{CH}^4)}{\frac{1}{0.9} + \frac{1}{0.5} - 1} = \frac{(.1714)\,(T_{CC}^4 - 5.45^4)}{\frac{1}{0.5} + \frac{1}{0.95} - 1} + (300\,T_{CC} - 1635)$$

$$= (100)(0.6)\,\frac{(T_{CH} - T_{CC})}{.25} = 240(T_{CH} - T_{CC})$$

SEPARATING EQNS:

$$(0.0812)(19.6^4 - T_{CH}^4) = (0.0835)(T_{CC}^4 - 5.45^4) + (300\,T_{CC} - 1635)$$

$$(0.0812)(19.6^4 - T_{CH}^4) = 240(T_{CH} - T_{CC})$$

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CALCULATION SHEET

SHEET NO. H2 OF......			
DESCRIPTION EMP. ENERSOLVE - STANTON PIPES	PROJ. NO. 9036	MADE BY CK DATE	CHECKED BY DATE

FROM EQN. ②,

$$11{,}983 - 0.0812\, T_{CH}^4 = 240\, T_{CH} - 240\, T_{CC}$$

$$240\, T_{CC} = 240\, T_{CH} + 0.0812\, T_{CH}^4 - 11{,}983$$

$$\underline{T_{CC} = T_{CH} + (3.38)10^{-4} T_{CH}^4 - 50} \qquad ③$$

FROM EQN. ①,

$$11{,}983 - 0.0812\, T_{CH}^4 = 0.0835\, T_{CC}^4 - 74 + 300\, T_{CC} - 1635$$

$$300\, T_{CC} = 13{,}692 - 0.0812\, T_{CH}^4 - 0.0835\, T_{CC}^4$$

$$\underline{T_{CC} = 45.64 - (2.71)10^{-4}\, T_{CH}^4 - (2.78)10^{-4}\, T_{CC}^4} \; ④$$

SOLVING EQTNS. ③ & ④ BY TRIAL & ERROR GIVES:

$T_{CH} = 18.7 \rightarrow 1410$ °F

$T_{CC} = 9.7 \rightarrow 510$ °F

Q_{LOSS} FOR 1 END

$$= (24 \times 3)\, 240\, (18.7 - 9.7) = \underline{(0.16)\ \text{MMBTU/HR}}$$

$$q \simeq \underline{2{,}200\ \text{BTU/h-ft}^2}$$

HATCH ASSOCIATES Consulting Engineers	CALCULATION SHEET			SHEET NO 43 OF
DESCRIPTION EMR ENERSOLVE - STANTON PIPES		PROJ. NO. 9036	MADE BY DATE	CHECKED DATE

FOR $\varepsilon_c = 0.8$

$$(0.1259)(19.6^4 - T_{CH}^4) = (0.1316)(T_{cc}^4 - 5.45^4) + (300\,T_{cc} - 1635) \qquad \text{(1A)}$$

$$(0.1259)(19.6^4 - T_{CH}^4) = 240\,(T_{CH} - T_{cc}) \qquad \text{(2A)}$$

FROM EQN. (1A)

$$18{,}580 - 0.1259\,T_{CH}^4 = 0.1316\,T_{cc}^4 - 116 + 300\,T_{cc} - 1635$$

$$300\,T_{cc} = 20{,}331 - 0.1259\,T_{CH}^4 - 0.1316\,T_{cc}^4$$

$$\underline{T_{cc} = 67.8 - (4.20)10^{-4}\,T_{CH}^4 - (4.39)10^{-4}\,T_{cc}^4} \qquad \text{(3A)}$$

FROM EQN. (2A),

$$18{,}580 - 0.1259\,T_{CH}^4 = 240\,T_{CH} - 240\,T_{cc}$$

$$\underline{T_{cc} = T_{CH} + (5.25)10^{-4}\,T_{CH}^4 - 77.4} \qquad \text{(4A)}$$

TRIAL & ERROR SOLUTION GIVES:

$T_{CH} \cong 19.0 \rightarrow 1440\ ^\circ F$

$T_{cc} \cong 9.4 \rightarrow 480\ ^\circ F$

Q_{LOSS} FOR ONE END

$$= (24 \times 3)\,240\,(19 - 9.4) = \underline{(0.17)\ \text{MMBTU/HR}}$$

NOT SIGNIFICANTLY DIFFERENT
THAN FOR $\varepsilon_c = 0.5$

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CALCULATION SHEET

SHEET NO. H4 OF.....			
DESCRIPTION EMR. ENERSOLVE - STANTON	PROJ. NO. 9036	MADE BY SK DATE APR./85	CHECKED BY DATE

COST FOR INSULATING STEEL CURTAIN AT CHARGE DOOR

TELEPHONE QUOTE FROM PLIBRICO (639-8660) FOR
GL-144T FIBERFRAX CERAMIC TAPE 1/8" x 6"
= #12.00/ft

MAXIMUM CONTINUOUS USE TEMPERATURE = 2000 °F

$$COST/FT^2 = \frac{\#12}{0.5} = \#24/ft^2$$

ALLOW #35/FT² INSTALLED

∴ TOTAL COST FOR TWO LAYERS AT CHARGE DOOR
$= (24 \times 3) \times 70 \cong \underline{\#5000}$

APPENDIX I

COMPLETED QUESTIONNAIRES FROM
SURVEY ON FUEL USAGE
(IN ALPHABETICAL ORDER)

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: A-1 STEEL (SASKATOON)
GEORGE P. [illegible]
(306) 931-8090

PRODUCTS: IRON (25%) & STEEL (75%) CASTINGS FOR TRUCKING, PULP & PAPER, AGRICULTURE, MINES

- JOBBING FOUNDRY

CURRENT PRODUCTION:
(tons/month)
100 TPM

RATED PRODUCTION:
(tons/month)
300 TPM

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)
- NO OIL USED
- NATURAL GAS USERS : LADLE HEATING
HEAT TREAT OVEN
BOILER
AIR MAKE UP UNITS

TOTAL MONTHLY CONSUMPTION : 15,000 m³ IN SUMMER + [illegible] IN WINTER.
NOV. '82 CONSUMPTION = 39,750 m³ FOR ENTIRE PLANT
AUG. '82 CONSUMPTION = 22,000 m³ " " "

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT? NO - HAVE 2 INDUCTION MELTING FURNACES

AIR PREHEAT TEMP:
—

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
BATCH - CAR BOTTOM TYPE; 4-7 HRS. CYCLE; 4-T BATCH (6'×12'×8')

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:
1 SHIFT/DAY
5 DAYS/WK.

OPERATING TEMPERATURE:
2250 °F MAX.

IS FLUE GAS COLLECTED?
YES - CHIMNEY TO ATMOSPHERE

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?
NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)
-NOT GOOD AT PRESENT
-REFRACTORY [illegible]

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)
GENERALLY GOOD

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:
10 BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED?
AUTOMATIC

HOW IS FUEL INPUT CONTROLLED?
THERMOCOUPLE [illegible] TO AN AUTOMATIC CAM CONTROLLED.

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?
—

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH
ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: ABEX - JOLIETTE
JOHN MILLER, MAINTENANCE
(514) 756 - 4531

PRODUCTS: STEEL CASTINGS FOR MINING, PULP & PAPER, PETROCHEMICAL & RAILWAY INDUSTRIES

CURRENT PRODUCTION:
(tons/month) 600

RATED PRODUCTION:
(tons/month) 1000

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NAT. GAS : ONE ANNEALING FURNACE (15 TPH)
OIL : FOUR ANNEALING FURNACES (25 TPH ea.)
@ ≃ 7.6 MMBTU/T

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT? NO

AIR PREHEAT TEMP: —

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
BATCH - CAR BOTTOM

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

OPERATING TEMPERATURE: UPTO 2000 °F

IS FLUE GAS COLLECTED? ?

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.) REFRACTORY + BLANKETS. STUDYING IMPROVING THE INSULATION.

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses) REASONABLY GOOD.

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:
No.1 FCE (OIL) : 18 BURNERS, 10 MMBTU/H
2-4 (OIL) : 6 BURNERS EA, 8 MMBTU/H EA.
5 (NG) : 16 BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED?
AUTOMATIC

HOW IS FUEL INPUT CONTROLLED?
AUTOMATIC BY THERMOCOUPLE

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?
NO

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

ABEX - SELKIRK
JOEL OLEKSON, ASST. PLANT MGR.
STAN TRIPPIER, MAINTENANCE
(204) 453-2322

PRODUCTS:

IRON & STEEL CASTINGS FOR RAILWAYS, MINING INDUSTRIES

CURRENT PRODUCTION:
(tons/month) 180

RATED PRODUCTION:
(tons/month) 300

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

OIL USED AS BACK-UP ONLY
NATURAL GAS - HEAT TREAT FCES. (HAVE 5 OF WHICH ONLY 3 USED)
- SPACE HEATING

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

—

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CAR - BOTTOM BATCH

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

OPERATING TEMPERATURE:
VARIES : 500 °F → 1950 °F

IS FLUE GAS COLLECTED?
YES - VENTED TO ATMOSPHERE

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?
NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)
GOOD → REFRACTORY - BLANKET

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)

BURNER CONTROL

- **NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:**
- **HOW IS AIR/FUEL RATIO CONTROLLED?**
- **HOW IS FUEL INPUT CONTROLLED?**
- **IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?**

MR. TRIPPIER
COULD NOT BE
CONTACTED FOR
THIS INFO.

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH
ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: CANRON – FOUNDRY DIVISION (INGOT MOULDS)

PRODUCTS: IRON CASTINGS - INGOTS

CURRENT PRODUCTION:
(tons/month) 8000 N.T./MONTH

RATED PRODUCTION:
(tons/month) 9600 N.T./MONTH

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

[illegible] DRIER

[illegible]

[illegible]

IF YOU HAVE A CUPOLA, — [illegible] — CURRENT [illegible]
IS THERE AIR PREHEAT? ——

AIR PREHEAT TEMP: —

IF YOU HAVE HEAT TREAT FURNACE(S): NO

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS
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QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:
CANRON - PIPE DIVISION, TORONTO

PRODUCTS:
CAST & GRAY IRON PIPES

CURRENT PRODUCTION:
(tons/month)
2500

RATED PRODUCTION:
(tons/month)
~ 3200

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

- OIL USED ONLY AS BACK-UP
- NAT. GAS USERS:
  - ANNEALING FCE. (40% OF TOTAL)
  - SCRAP PRE-HEATER + AFTER-BURNER

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?
—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CONTINUOUS

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION: 24 h/d, 5 d/wk

OPERATING TEMPERATURE:
UPTO 1900 °F

IS FLUE GAS COLLECTED?
DISCHARGED TO ATMOSPHERE

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.) GOOD - MOSTLY CERAMIC FIBRE

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses) POOR.

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS: 17 TOTAL BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED? NOT CONTROLLED

HOW IS FUEL INPUT CONTROLLED?
BY THERMOCOUPLE

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

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ASSOCIATES
HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

CDN. STEEL FOUNDRIES (HAWKER SIDDELEY)
ROBERT PERREAULT, PLANT ENGG
(514) 255-4041

PRODUCTS:

Carbon, alloy & stainless steels for railway, mining, energy & mfg. industries

CURRENT PRODUCTION:
(tons/month)

2100 TPM

RATED PRODUCTION:
(tons/month)

3600

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NO OIL

1983 consumption $\simeq (2.37)\ 10^{11}$ BTU/yr

Ladle preheaters: 10 % $\cong (2.4)\ 10^{10}$ BTU/yr

Boiler (space htg): 15 % $\simeq (3.6)\ 10^{10}$ BTU/yr

Space & Air Heaters: 5 % $\simeq (1.2)\ 10^{10}$ BTU/yr

Annealing fces : 70 % $\simeq (16.2)\ 10^{10}$ BTU/yr $\Rightarrow 6.4\ \frac{\text{MMBTU}}{\text{T}}$

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

NO CUPOLA

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:	Car bottom type (15 fces)
NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:	Average: each fce. used once a week.
OPERATING TEMPERATURE:	upto 2200°F
IS FLUE GAS COLLECTED?	Most of them have a chimney for exhausting gas
IS THERE WASTE HEAT RECOVERY ON FLUE GAS?	No
WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)	Well insulated Most are adequately, some ceramic fibre
WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)	Good Condition

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:	—
HOW IS AIR/FUEL RATIO CONTROLLED?	Manual - Adjusted [illegible]
HOW IS FUEL INPUT CONTROLLED?	Both air & gas are manually controlled
IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?	

Have very low fce. efficiency but difficult to improve due to low utilization.

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: CRANE CANADA INC. , BRANTFORD
E. BOUDREAU, PLANT MGR.
(519) 759-3911

PRODUCTS: VALVES AND PLUMBING BRASS FIXTURES

ALL BRASS
5 d/wk , 1.5 shifts/day

CURRENT PRODUCTION: (tons/month) 360 TONS

RATED PRODUCTION: (tons/month) 720 TONS

MAJOR OIL AND NATURAL GAS USERS: (and typical consumption if available)

1. MOLTEN METAL TRANSFER LAUNDERS AND POURING SHUTTLEBOXES
2. MAKEUP AIR UNITS
3. LOW PRESSURE BOILER

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT? N/A

AIR PREHEAT TEMP: N/A

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:	N/A
NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:	N/A
OPERATING TEMPERATURE:	N/A
IS FLUE GAS COLLECTED?	N/A
IS THERE WASTE HEAT RECOVERY ON FLUE GAS?	N/A
WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)	N/A
WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)	N/A

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:	7 ZONES FOR AIR MAKEUP 12 BURNERS
HOW IS AIR/FUEL RATIO CONTROLLED?	MANUAL ADJUSTMENT
HOW IS FUEL INPUT CONTROLLED?	MANUALLY
IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?	NO

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH
ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: DAYTON - WALTHER, GUELPH

TOM WALPOLE (519) 824-3350

MR. TRUDEAU (PERSONNEL MGR)

PRODUCTS:

IRON, STEEL CASTINGS FOR AUTO INDUSTRY

CURRENT PRODUCTION:
(tons/month)

1600

RATED PRODUCTION:
(tons/month)

1600

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if
available)

NO OIL

NATURAL GAS: - ANNEALING OVEN

- LADLE PREHEATING

(CONSUMPTIONS UNKNOWN)

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CONTINUOUS - PARTS SUSPENDED FROM A CONVEYING MECHANISM.

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION: 2 SHIFTS/DAY, 5 DAYS/WK.

OPERATING TEMPERATURE: 1650 °F

IS FLUE GAS COLLECTED? IN A CHIMNEY

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? YES - FOR HEATING PLANT AIR. FLUE GAS TEMP. AFTER HX NOT KNOWN

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.) CERAMIC FIBRE, GOOD INSULATION

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through which there are heat losses) DOORS WIDE OPEN, NO CURTAINS

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS: 3 ZONES EACH WITH OWN SET-POINTS.

HOW IS AIR/FUEL RATIO CONTROLLED? YES - AUTOMATIC

HOW IS FUEL INPUT CONTROLLED? BY THERMOCOUPLE

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

ESCO - PORT COQUITLAM. B.C.
BOB BOYER
(604) 942-7261

PRODUCTS:

STEEL CASTINGS FOR TRANSPORTATION INDUSTRY

CURRENT PRODUCTION:
(tons/month)

800 (38 TPD)

RATED PRODUCTION:
(tons/month)

1100

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NO OIL USED

NAT. GAS: - 3 CAR-BOTTOM FCES. (60% TOTAL NG)
RATED AT 9 MMBTU/h., 8 MMBTU/h. &
6 MMBTU/h.

- LADLE DRYERS

(CONSUMPTIONS NOT READILY AVAILABLE)

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
BATCH - CAR BOTTOM ; 5-6 T/CHARGE ; 4 h. CYCLE

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:
24 h/day, 5 days/wk.

OPERATING TEMPERATURE:
1900 - 2050 °F

IS FLUE GAS COLLECTED?
YES - VENTED TO ATMOSPHERE

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?
NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)
GOOD - CERAMIC FIBRE
SHELL TEMP. ≈ 125 °F

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)
GOOD

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:
6 BURNERS IN SMALL FCE.
8 BURNERS EA. IN LARGER FCES.

HOW IS AIR/FUEL RATIO CONTROLLED?
AUTOMATICALLY

HOW IS FUEL INPUT CONTROLLED?
BY THERMOCOUPLE

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?
?

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ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

FAHRAMET - ORILLIA
DAVE BRANCH - PLANT MGR.
JOHN McCORMICK - MAINTENANCE SUPT.
(705) 325-2781

PRODUCTS:

STEEL CASTINGS

CURRENT PRODUCTION:
(tons/month) 400

RATED PRODUCTION:
(tons/month) 600

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

OIL NOT USED
NAT. GAS: - LADLE PREHEATERS;
- HEAT TREAT FCES.
(4/7 AVAILABLE)

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CAR BOTTOM - BATCH

NO. OF HOURS/DAY, AND DAYS/WEEK
OPERATION:

OPERATING TEMPERATURE:
3 @ 2100°F
1 @ 1300°F

IS FLUE GAS COLLECTED?
NO

IS THERE WASTE HEAT RECOVERY
ON FLUE GAS?
NO

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)
- 2 NEW RETROFIT FCES (2100°F) TO BE COMPLETELY CERAMIC FIBRE
- 1 LOW TEMP. FCE. IS REFRACTORY + STEEL
- OTHER HI-TEMP. FCE. IS CERAMIC FIBRE ROOF & REFRACTORY WALLS, HEARTH

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through
which there are heat losses)
USABLE FCES. IN GOOD SHAPE

BURNER CONTROL

NO. OF ZONES OF BURNERS
AND NO. OF TOTAL BURNERS:
6 BURNERS EA.

HOW IS AIR/FUEL RATIO CONTROLLED?
AUTOMATICALLY

HOW IS FUEL INPUT CONTROLLED?
BY A THERMOCOUPLE

IS FUEL CONSUMPTION CONTINUOUSLY
MONITORED?

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: FONDERIE STE. CROIX
MR. BIRON, PLANT MGR.
(418) 926-3262

PRODUCTS:

GRAY IRON CASTINGS for FITTINGS,
PIPES, HIGH VOLUME JOBBING

CURRENT PRODUCTION:
(tons/month)

2000 TPM TOTAL

RATED PRODUCTION:
(tons/month)

$\frac{2000}{0.65} \doteq 3000$ TPM

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

OIL NOT USED
NAT. GAS - hot blast on cupola: $15,000/mo.
- shell [illegible] machines (most of
to #14,000/month machines)
- Ladle heating: #4000/mo.
- Building heating: #8000/month annual avg.
- No heat treat fces.

9 HRS/DAY,
20 DAYS/MO.

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

YES

AIR PREHEAT TEMP:

500 °F

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK
OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY
ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through
which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS
AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY
MONITORED?

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

FORD MOTOR CO. - ALUMINUM CASTING PLANT
WINDSOR
DOUG HARRIS (519) 944-8513

PRODUCTS:

Al. Casting - Cylinder heads, Pistons

CURRENT PRODUCTION:
(tons/month)

358,000 lbs/day = 180 TONS/DAY
(6 DAYS/WK) AT 25 DAYS/MO. → 4500 TPM

RATED PRODUCTION:
(tons/month)

Close to it

500,000 lbs/day

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NO OIL USED

NAT. GAS - CUPOLA (JET MELTER)
- ROTARY MELTING FCES.
- 3 REVERB HOLDING FCES.

} NO WASTE HEAT RECOVERY

NO HEAT TREAT FCES.

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

No Air pre-heat on cupola.

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK
OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY
ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through
which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS
AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY
MONITORED?

HATCH ASSOCIATES

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:
FORD – IRON CASTING PLANT
WINDSOR ; MAX JACKSON
MFG. PLANT ENGR. (519) 257-4540

PRODUCTS:
GREY & DUCTILE IRON CASTINGS
FOR AUTO PARTS

CURRENT PRODUCTION:
(tons/month)
140,000 TONS/YR. ≅ 12,000 TPM

RATED PRODUCTION:
(tons/month)
ABOVE

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)
NO OIL
N. GAS
→ SPACE HEATERS
→ BOILER
→ CORE DRYERS
→ ANNEALING FCES (2) ≈ 5% TOTAL N.G.
→ HOT BLAST (MOST OF N.G.)

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?
YES, ON BOTH CUPOLAS

AIR PREHEAT TEMP:
1000 °F,
1100 °F

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CONTINUOUS – CONVEYOR CARRIES PARTS THROUGH THE FURNAC
≃ 5 TPH ea.

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION: 16 H/DAY, 6 DAYS/WK

OPERATING TEMPERATURE: 1400 °F

IS FLUE GAS COLLECTED? NO

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.) GOOD – Ceramic Fibre

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)
Good
Gravity type arrangement for closing & lowering [illegible]

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS: 4 ZONES/FCE.

HOW IS AIR/FUEL RATIO CONTROLLED? MANUALLY SET-UP

HOW IS FUEL INPUT CONTROLLED? BY TEMPERATURE

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

GM OF CANADA LTD., ST. CATHARINES FOUNDRY
MR. GERALD GILES, FOUNDRY MANAGER (+ RAY VISH)
685 - 2507

PRODUCTS:

NODULAR AND GRAY IRON AUTOMOTIVE PARTS - FOR ENGINES, POWER TRAIN, SUSPENSION AND BRAKING SYSTEMS

CURRENT PRODUCTION:
(tons/month)

55,000 TO 65,000 TONS POURED/MONTH

1410 TPD × 21 = 30,000 TONS CASTINGS PRODUCED
(50% YIELD)
50% OF IT THROUGH HEAT TREAT FCE.

RATED PRODUCTION:
(tons/month)

CURRENT PRODUCTION LEVEL IS ABOUT 115% OF STANDARD VOLUME

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

PROCESS GAS USAGE AT CURRENT VOLUMES IS AS FOLLOWS (APPROX.)

CUPOLA HOT BLAST - 4 UNITS - TOTAL 40,000 MCF/MONTH
LADLE PREHEATING 2,000 MCF/MONTH
HEAT-TREAT FURNACES 8,000 MCF/MONTH
CORE ROOM PROCESSES 9,000 MCF/MONTH
CUPOLA EMISSION CONTROL 11,000 MCF/MONTH
HOT BRIQUETTING PROCESS 3,000 MCF/MONTH
OIL IS USED ONLY AS BACK-UP FUEL AGAINST GAS SHORT-FALL.

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

FOUR CUPOLAS, ALL WITH HOT BLAST, TWO WITH RECIRCULATING BLAST PREHEATERS.

AIR PREHEAT TEMP:

900 TO 1200° F

IF YOU HAVE HEAT TREAT FURNACE(S): 1 RADIANT AND 1 DIRECT HEATED

TYPE OF OPERATION [BATCH/CONTINUOUS]: CONTINUOUS

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:
5 TO 6 DAYS/WEEK, 3 SHIFTS/DAY

OPERATING TEMPERATURE: 1200 TO 1600° F

IS FLUE GAS COLLECTED? YES

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? NO

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)
APPROX. 200°F

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through which there are heat losses)
POOR ON RADIANT FURNACE (OPEN END)
GOOD ON DIRECT FURNACE

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:
RADIANT - 8 ZONES, 51 BURNERS
DIRECT - 3 ZONES, 32 BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED?
RATIO REGULATORS, AIR LEAD

HOW IS FUEL INPUT CONTROLLED? RATIO REGULATORS, FOLLOWING COMBUSTION AIR

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED? YES

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HATCH ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

GRIFFIN - ST. HYACINTHE
J.M. GUERTIN, PLANT MGR.
(514) 774 - 5311

PRODUCTS:

STEEL CASTINGS

CURRENT PRODUCTION:
(tons/month)

1750

(PLANT STARTED UP IN APRIL AT 70% CAPACITY.
PRODN: 33 WHEELS @ 800 LB/HR,
21 HEATS PER DAY)

RATED PRODUCTION:
(tons/month)

2500

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NAT. GAS - NOT AVAILABLE UNTIL NEXT OCT. COST ANALYSIS BEING DONE FOR OIL→NG CONVERSION

OIL USERS:

- ONE 40' DIA. ROTARY FCE. FOR ANNEALING CASTINGS (20,000 GALL/WK @ FULL USE ≃ 19.5 MMBTU/H)
- BOILER FOR SPACE HEATING IN WINTER, NO WASTE HEAT RECOVERY, CONSIDERING CONVERSION TO ELECTRIC

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CONTINUOUS

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION: 24 h/DAY, 6 DAYS/WK.

OPERATING TEMPERATURE:
900 - 1700 °F

IS FLUE GAS COLLECTED?
NO - EXHAUSTS INTO PLANT

IS THERE WASTE HEAT RECOVERY ON FLUE GAS? NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.) SHELL TEMP. ≃ 400-500 °F
HAVE 3-4 ROWS OF BRICK

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses) POOR - 3'x4' OPENING AT BOTH ENDS

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS: 4 ZONES, 32 BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED?
AUTOMATICALLY

HOW IS FUEL INPUT CONTROLLED?
BY THERMOCOUPLE - AUTOMATIC

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH
ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:
GRIFFIN - WINNIPEG
ART SMITH, MAINTENANCE SUPERVISOR
(204) 222- 4252

PRODUCTS:
STEEL WHEELS

CURRENT PRODUCTION:
(tons/month)
CONFIDENTIAL
ESTIMATE ≃ 3500 TPM

RATED PRODUCTION:
(tons/month)
1000 WHEELS/DAY
4800 TPM → FROM EMR ELLIS INVENTORY

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)
- NO OIL USED
- PROPANE STANDBY
- NAT. GAS USERS:
  HEAT TREAT {
  - 92' DIA. ROTARY FCE. - NORMALIZING
  - 2 DRAW TEMPERING FCES.
- WINTERTIME BILL ≃ $150,000/MONTH
- CONSUMPTIONS ARE CONFIDENTIAL

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?
—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:

ALL ARE CONTINUOUS

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

CONFIDENTIAL; DRAW FCES. USED OCCASIONALLY ONLY

OPERATING TEMPERATURE:

NORMALIZING : 1800 °F
DRAW FCES : 900 °F

IS FLUE GAS COLLECTED?

NORMALIZING FCE - YES
DRAW FCES - EXHAUSTS INSIDE BLDG.

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?

NORMALIZING FCE - PART OF GASES USED FOR COMB. AIR PREHEATING TO 600 °F IN FIRST ZONE.

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)

GOOD

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)

GOOD - DOOR ON ENDS OF ALL FCES.

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:

8 ZONES IN NORMALIZING FCE.
3 ZONES EA IN DRAW FCES.

HOW IS AIR/FUEL RATIO CONTROLLED?

AUTOMATIC

HOW IS FUEL INPUT CONTROLLED?

INDIVIDUALLY BY THERMOCOUPLE IN EACH ZONE

IS FUEL CONSUMFTION CONTINUOUSLY MONITORED?

EACH EQUIPMENT HAS ITS OWN METER.

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

ITT AIMCO
(416) 688-1754
ST. CATHERINES

ANDY SCHERTZER, FOUNDRY SUPT.
JOHN WARNER, ENGG.

PRODUCTS:

IRON CASTINGS FOR AUTOMOTIVE INDUSTRY

CURRENT PRODUCTION:
(tons/month) 200 TPD @ 20 DAYS = 4000 TPM

2 SHIFTS/DAY, 5 DAYS/WK.

RATED PRODUCTION:
(tons/month) AS AT CURRENT

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available) OIL NOT USED

WARNER, ENGG.

NAT. GAS :

- HOT BLAST PREHEAT ON CUPOLA
- AFTERBURNER ON CUPOLA
- PLANT HEATING

- NO HEAT TREAT FCES.

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

YES

AIR PREHEAT TEMP:

600 F

IF YOU HAVE HEAT TREAT FURNACE(S): NO

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK
OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY
ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through
which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS
AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY
MONITORED?

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH
ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

MARITIME STEEL & FOUNDRIES - NEW GLASGOW
JACK FUQUA, PLANT SUPT.
(902) 752-1511

PRODUCTS:

STEEL CASTINGS

CURRENT PRODUCTION:
(tons/month) 150

RATED PRODUCTION:
(tons/month) 250

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

- NO NAT. GAS USED

- OIL : 3 CAR BOTTOM HEAT TREAT FCES.
LADLE PREHEATING

IF YOU HAVE A CUPOLA,
IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:
CAR BOTTOM - BATCH ; 10 T. LOAD EA.

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

OPERATING TEMPERATURE:
1600°F

IS FLUE GAS COLLECTED?
YES

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?
NO

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)
GOOD - CERAMIC FIBRE

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)
GENERALLY GOOD

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:
5 ZONES, 8 BURNERS

HOW IS AIR/FUEL RATIO CONTROLLED?
MANUAL → 2-3 TIMES PER DAY

HOW IS FUEL INPUT CONTROLLED?
MANUAL INDIVIDUAL CONTROLS

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?
DONE BY MAINTENANCE

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

HATCH ASSOCIATES

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME: McCOY FOUNDRIES, TROY

DANNY NEMO (519) 647-3411
FOUNDRY SUPT.

PRODUCTS:

Grey Iron Castings
- Catch Basins, machine castings, forklift parts

CURRENT PRODUCTION:
(tons/month)

60 TPD / 300 TPWK.
1200 - 1500 TPM

RATED PRODUCTION:
(tons/month)

100 TPD

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

NAT. GAS: JUST BECAME AVAILABLE, ALL OIL TO BE CONVERTED TO NG
OIL : Mould core drying ovens, 4 BURNERS
Torches
space heating (major use), upto 5000 gallons/wk,

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

NO

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION? (estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS? (i.e. doors, cracks through which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY MONITORED?

HATCH ASSOCIATES

HATCH ASSOCIATES LTD. CONSULTING ENGINEERS

QUESTIONNAIRE ON FUEL USAGE

COMPANY NAME:

SYSCO - SYDNEY (902-564-5471)
JOHN HODGSON, FOUNDRY SUPT

PRODUCTS:

MOST OF PROD'N
CAST IRON & STEEL CASTINGS
(FOUNDRY IS MAINTENANCE FOR MAJOR OPERATIONS)

CURRENT PRODUCTION:
(tons/month)

IRON: 50 TPD ≃ 1000 TPM
STEEL: 82,000 $\frac{\text{lb}}{\text{mo}}$ = 40 $\frac{\text{T}}{\text{MONTH}}$.

RATED PRODUCTION:
(tons/month)

STEEL: 15 $\frac{\text{TONS}}{\text{WK}}$; IRON: 100 TPD

MAJOR OIL AND NATURAL GAS USERS:
(and typical consumption if available)

- MOULD DRYING OVENS → PROPANE, CONSUMPTION NOT MONITORED
- NO HEAT TREAT FCES. LEFT
- HOT METAL FROM PRIMARY OPERATIONS

IF YOU HAVE A CUPOLA, IS THERE AIR PREHEAT?

—

AIR PREHEAT TEMP:

IF YOU HAVE HEAT TREAT FURNACE(S):

TYPE OF OPERATION [BATCH/CONTINUOUS]:

NO. OF HOURS/DAY, AND DAYS/WEEK
OPERATION:

OPERATING TEMPERATURE:

IS FLUE GAS COLLECTED?

IS THERE WASTE HEAT RECOVERY
ON FLUE GAS?

WHAT IS LEVEL OF THERMAL INSULATION?
(estimated shell temp.)

WHAT IS CONDITION OF FURNACE SEALS?
(i.e. doors, cracks through
which there are heat losses)

BURNER CONTROL

NO. OF ZONES OF BURNERS
AND NO. OF TOTAL BURNERS:

HOW IS AIR/FUEL RATIO CONTROLLED?

HOW IS FUEL INPUT CONTROLLED?

IS FUEL CONSUMPTION CONTINUOUSLY
MONITORED?